# WATER WELLS AND GROUND WATER SUPPLIES IN ONTARIO

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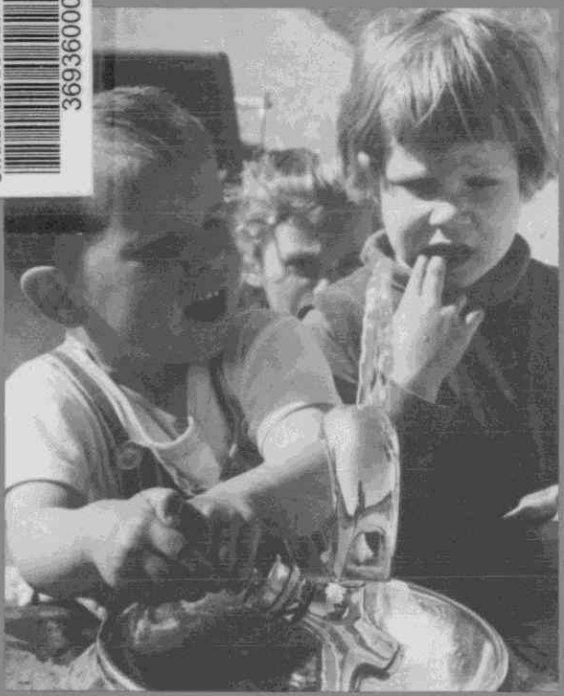

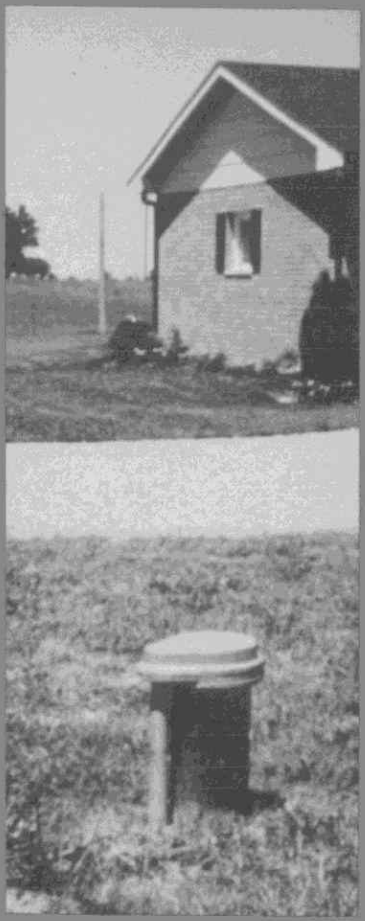

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Ministry of the Environment
Ontario

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# WATER WELLS AND GROUND WATER SUPPLIES IN ONTARIO

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Water Resources Branch
Ontario Ministry of the Environment
135 St. Clair Avenue, West
Toronto, Ontario, M4V 1P5.

All Ontario Ministry of the Environment Regional and District Offices
(addresses listed in Appendix A).

Ontario Government Bookstore and Publications Centre
880 Bay Street
Toronto, Ontario, M5S 1Z8.

## FOREWORD

This publication is intended as a guide for existing or potential users of ground-water supplies. Included is basic information on factors which affect the occurrence, the quantity and the quality of ground water, a synopsis on well construction, and a discussion of common problems associated with wells and water-supply systems. In addition, the existing Ontario Water Well Regulations are discussed with respect to the well owner and the water-well contractor. It should be stressed that this guide is not intended as a manual on well construction nor a manual on pump installation since both of these operations require considerable background training and experience.

## METRIC CONVERSION FACTORS

| Multiply English Units | By | To Obtain Metric Units |
|---|---|---|
| Inches (in) | 2.540 | Centimetres (cm) |
| Feet (ft) | 0.305 | Metres (m) |
| Gallons per minute (gpm) | 0.758 | Litres/sec |
| Gallons per day (gpd) | $5.262 \times 10^{-5}$ | Litres/sec (L/s) |
| Pounds/sq.inch ($lb/in^2$) | 70.307 | Grams/sq. cm ($g/cm^2$) |

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# INTRODUCTION

An adequate water supply, a principal necessity of any residence, must be not only constant and dependable but also of a quality sufficient to meet all household demands.

There are two principal sources for a water supply: surface water sources, which include natural and man-made lakes, rivers, and streams, and ground-water sources which include both water from wells and that issuing from the ground in springs. The ground-water source and water-supply systems using this source will be discussed in the following pages.

Ground water can provide a relatively inexpensive and constant supply of potable water. It is less susceptible to contamination than surface water and for the most part has a near constant yearly temperature ranging from 8-12°C (46-54°F), unlike surface water which may fluctuate considerably with changes in the seasonal temperature. Most ground water in Ontario requires no chemical treatment after being pumped from the well.

The process of finding a ground-water source has changed considerably. Ground water was once located almost exclusively by "water witching", a method which has no scientific basis. Today, modern hydrogeologic methods have increased the probability of finding a good source of ground water in many locations. Finding a ground-water source is, after all, not a mystical process but rather one using a systematic approach, requiring the examination of all available information and then making a rational decision.

The construction of water wells has also changed considerably since the time when they were dug with pick and shovel to depths of a few tens of feet. Using modern drilling methods, wells may reach depths of 600 feet or more. Similarily, most water wells and water-supply systems today are more reliable than their predecessors. A properly constructed well will probably never go dry or be contaminated by leakage from shallow polluting sources such as septic systems or surface drainage.

## THE HYDROLOGIC CYCLE

The "hydrologic cycle" or water cycle, illustrated in Figure 1, is the complex cycle of events in the natural environment which involves the movement of water as water vapor, rain, snow, surface water and ground water. This cycle of events, although it has no real beginning and no end, can be assumed to start with the evaporation of water from oceans, lakes, rivers and the soil by the sun's energy.

The water vapor condenses to form small droplets which are kept airborne in clouds. Changes in atmospheric temperature or pressure create an imbalance in the droplets resulting in them falling to the ground as rain or snow (precipitation). A large part of this precipitation is retained temporarily in the soil and is eventually returned to the atmosphere through evaporation or transpiration by plants. A portion runs off the land into rivers, lakes, or oceans, while the remainder moves downward to the watertable to eventually become ground water.

## GROUND WATER

Water falling on the ground surface and infiltrating into the ground, moves downward through the soil until it reaches the zone of saturation. In the zone of saturation, water fills the pore spaces between grain particles and crevices or fractures in rock. The upper surface of the zone of saturation is called the watertable. The depth to the watertable depends on the type of material, the season and the slope of the ground surface. It may vary from a few feet below the surface to tens of feet. The sub-surface environment through which ground water moves is illustrated in a general way in Figure 2. The terminology is defined below.

Any underground material or formation in the zone of saturation, which is capable of yielding water to wells in usable quantities, is called an aquifer (it may also be referred to here as a water-bearing formation). Aquifers may occur in either the bedrock or in the unconsolidated material (overburden covering the bedrock). Aquifers in overburden often consist of sand and/or gravel. Coarse gravel is a good aquifer while fine sand or silt yields water slowly and is therefore considered a poor aquifer. Aquifers vary in size: a small aquifer may only be able to supply the water needs of a single household, while a

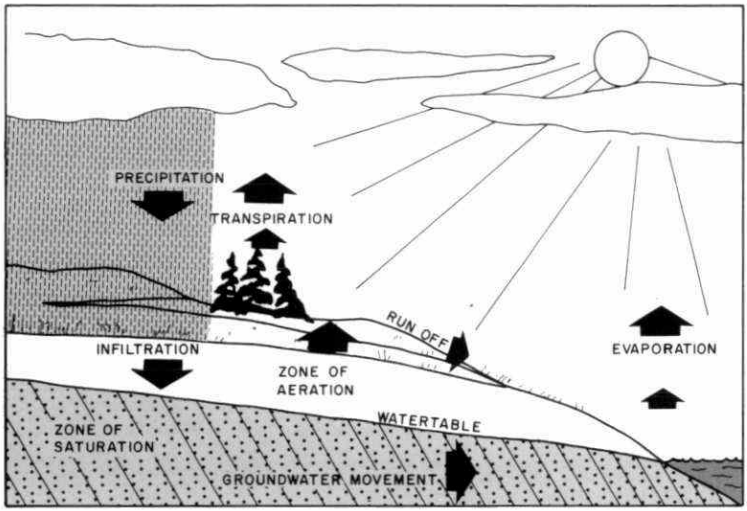


FIGURE 1 HYDROLOGIC CYCLE.

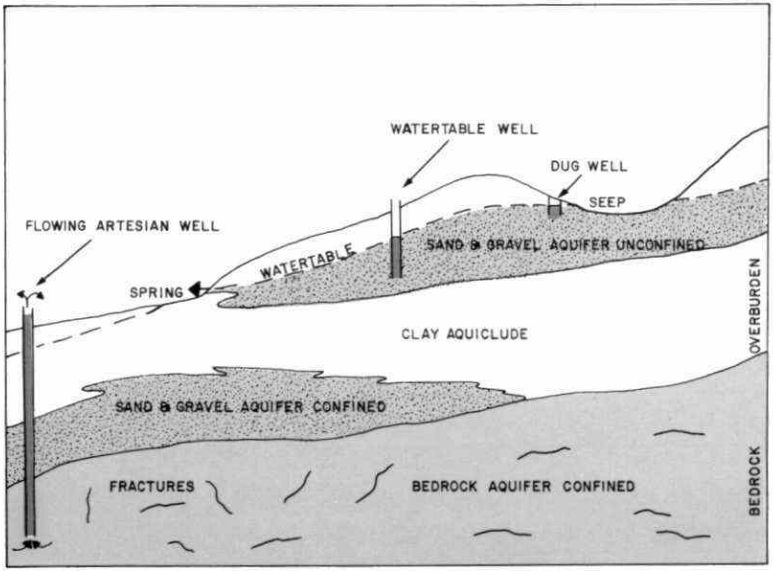


FIGURE 2 WATER-BEARING FORMATIONS

large aquifer may supply the water needs of a city.

In contrast, a formation which is saturated but does not yield water rapidly enough to furnish an adequate supply, is called an aquiclude. Examples of aquicludes would be clay and poorly fractured bedrock having few interconnected pore spaces.

Ground water is said to be confined when the aquifer (also known an an artesian aquifer) is overlain by materials or aquicludes which do not transmit water rapidly. Confined ground water is under pressure, in excess of atmospheric pressure. This is caused in part by the weight of the confining materials, in part by elevation differences in the aquifer and in part because the confining materials restrict the movement of water in the aquifer causing pressure to build up. When a confined aquifer is penetrated by a well the level to which the water rises in the well is dependent on the amount of pressure in the aquifer. A flowing well results where the water level rises above the ground surface.

## PLANNING A WATER SUPPLY

### WATER REQUIREMENTS

Once it has been decided that a well is the best means of providing an adequate water supply, it is necessary to determine the quantity of water required to meet household needs. Water requirements have increased considerably in the modern household and farm. Automatic clothes and dish washers and automated farm equipment increase demand. When planning a water-supply system, all present and anticipated future needs should be considered.

Water demands for a summer cottage will differ from that of a fully equipped family farm home. Residential water needs can be estimated to be 50 to 150 gallons per day per person. For a family of five this comes to about 750 gallons per day (at the higher rate). It is also important to take into account the demand during peak periods. If the peak demand is 30 gallons per minute (gpm) for a full hour, then the well must either be able to produce 30 gpm for a full hour or a water storage tank must be used which should have sufficient capacity to make up for any deficiency in well production. Additional information is provided in the section titled "Pumps".

Farm water requirements may be calculated by using the following table:

TABLE 1. APPROXIMATE WATER REQUIREMENTS

| | |
|---|---|
| Each member of the family (Kitchen, laundry, bath) | 50 to 150 gallons per day |
| each producing milk cow (including washing) | 15 gallons per day |
| dry cow | 12 " |
| steer | 10 " |
| horse | 12 " |
| hog | 3 " |
| sheep | 2 " |
| chickens (100) | 5 " |
| turkeys (100) | 12 " |

Irrigation requirements will not be discussed here. For information about irrigation you should contact your Regional Office of the Ontario Ministry of Agriculture and Food.

## PERMIT TO TAKE WATER PROGRAM

The Ontario Ministry of the Environment administers the Permit to Take Water Program under Section 37 of the Ontario Water Resources Act. For many major uses, a permit is required for the taking of more than 10,000 gallons of water a day from any source including a well. A permit is not required for the taking of water for domestic and general farm purposes. More detailed information and application forms for a Permit to Take Water are available at Ministry of the Environment (MOE) Regional Offices (addresses listed in Appendix A).

The main purpose of the permit legislation is to control the taking of water to promote its efficient development and beneficial use. The permit system is utilized to prevent water-supply interference problems where possible and to resolve them when this is not the case.

In an area where there is insufficient supply to meet established and new uses, an evaluation of the relative priority of the various uses is necessary. The taking of water for private domestic and farm purposes is considered the most important use, generally followed by takings for municipal water supply. The taking of water for industrial, commercial and irrigation purposes is regulated by the availability of the supply, efficiency of use and established uses in an area. With respect to water-well takings, the program is designed to provide protection to prior uses of the ground-water resource, a protection generally lacking under common law. Priority of time and the adequacy of an affected water supply prior to interference are basic considerations in assessing ground-water interference problems.

Taken together, these two factors mean that if a new water-well taking, under permit, interferes with another water supply obtained from an adequate well source which was in use prior to the date of issuance of the permit, the permittee is required to restore the affected supply or reduce the permitted taking so as to eliminate the interference. Well owners and operators who feel that their supply is being interfered with by a local water withdrawal should report this case to the appropriate Regional Office of the Ministry of the Environment. As well, when an individual is planning a major water-well supply, consideration should be given to its possible impact on existing local water uses.

## WATER AVAILABILITY AND SUPPLY

It is helpful to obtain as much information as possible on the geology and ground-water (hydrogeology) resources of the local area before constructing a well and if possible, recommendations regarding the reliability and workmanship of contractors in the area. In many areas of the Province, the hydrogeology is well-known and the information is available to you through a variety of sources.

The following may be useful in determining the availability of a ground-water supply:

1. types of wells in the area,
2. depths of wells,
3. types of bedrock or overburden materials encountered,
4. quantity of water available,
5. quality of water
6. ground-water reports and probability and major aquifer maps from the Ontario Ministry of the Environment (where available).

The above may be obtained from Ontario Ministry of the Environment Regional personnel, public utilities personnel, local drilling contractors, local agricultural representatives and neighbours.

### Water Resources Bulletins (Ground Water Series)

This series of publications presents water-well information for individual counties and regional municipalities in Ontario. This information consists of the data provided on water-well records submitted to the Ministry of the Environment (a copy of a blank record is presented in Appendix B). These data include the well locations, owners' names, dates of construction, geological logs, screens, water levels, well yields and water use. Also included are the names and addresses of licensed well contractors who have drilled the wells.

The area considered by each bulletin is presented in Appendix A along with the specific reference for that bulletin. Copies and/or microfiche of these bulletins are available from the Ontario Government Bookstore, 880 Bay Street, Toronto, Ontario or by mail from the Publications Centre, 5th Floor, 880 Bay Street, Toronto, Ontario, M5S 1Z8. The individual well records may be inspected at the Ministry of the Environment Regional Offices.

## Ground Water Probability Map Series

Ground-water probability maps are a non-technical series of maps published by the Ministry of the Environment. They are designed primarily for people who require water supplies from wells for domestic and livestock purposes.

Ground-water probability maps illustrate the availability of ground water in terms of the probably quantity of water available to water wells, the depth at which water is commonly found, and the quality of water at sample locations.

Since 1969, probability maps have been completed for the counties and regional municipalities of Essex, Lambton, Kent, Elgin, Haldimand-Norfolk, Brant and Peel. The areal coverage and specific references are presented in Appendix A.

Copies of the Ground Water Probability of Norfolk and the Ground Water Probability of Peel are available from the Ontario Government Bookstore (see section on Bulletins). Previously published maps are no longer available but can be viewed at Regional Offices of the Ministry.

## Major Aquifer Map Series

The Major Aquifer Series was designed to define aquifers of major areal extent and of significant water-production potential within southern Ontario. These maps are of assistance to those individuals wishing to establish a ground-water supply in that the maps provide data on the depth at which water has been found for those areas underlain by the aquifers. Also provided is information on the geology and the anticipated well yields of the aquifers.

Aquifers mapped are the Alliston Aquifer Complex (Map 77-1), the Oak Ridges Aquifer Complex (Map 78-2) and the Guelph - Amabel Aquifer Complex (maps 78-3, 78-4, 78-5, 78-6). The areal extent of these aquifers is illustrated in Appendix A along with the specific reference for each map.

## Water Resources Report Series

The Water Resources Report Series provide detailed information on the water resources of various drainage basins in the Province. These

reports are directed primarily at individuals such as well contractors, municipal planners, consultants and public utilities personnel who require such information as geology, overburden thicknesses, ground-water potential, theoretical water yields, hydrologic budgets, hydrochemistry and streamflow data.

Although these reports are more technically oriented than either the Ground Water Probability Map or the Major Aquifer Map series, they can still provide useful information to individuals who wish to have a well constructed. The areal coverage and specific references of these reports are presented in Appendix A. Although many of the reports are "out-of-print" in hard copy, microfiche copies can be obtained in person from the Ontario Government Bookstore, 880 Bay Street, Toronto, Ontario or by mail from the Publications Centre, 5th Floor, 880 Bay Street, Toronto, Ontario, M5S 1Z8.

## CHOOSING A SITE FOR A WELL

Care should be taken in choosing a site for a well, as well drilling is expensive and many well failures are indirectly caused by poor site location. For example a well may become contaminanted because it is located too close to a source of pollution such as a septic tank.

As a general rule, a well site should be located upslope and as far as possible from potential sources of pollution such as septic tanks, outhouses, barnyards and roads and highways. In addition, surface-water bodies such as lakes, streams and reservoirs may also be contaminated and can under certain circumstances, be a source of pollution. Well pumpage may draw in badly contaminated water from these sources. The following minimum distances are recommended for the spacing between any well and a potential pollution source:

| | |
|---|---|
| dug well ..... | 100 feet |
| drilled well with a water-tight casing to a depth of 20 feet ..... | 50 feet |

Whenever possible a well should be located at an elevation higher than that of the immediately surrounding area. This can be achieved by mounding the soil around the well. This is to prevent surface water, which may be polluted, from ponding in the vicinity of the well and

subsequently infiltrating, thereby contaminating it.

The location of existing and planned surface and underground structures on the property, such as buildings and septic systems, should be established before a contractor is hired and drilling is begun. Such information may eliminate future problems resulting from poor site location.

Property owners often drill or bore wells before construction begins on a house. This is an excellent idea, for if a satisfactory water supply cannot be found, they are able to change building plans. A well should not be located in any area (e.g. basement, below a paved driveway, under power lines, or under the eaves of a building) where it is extremely difficult to maintain the well or to remove the pump for repairs. Contact between a pipe being removed for maintenance and overhead power lines could electrocute the person holding the pipe. The Construction Safety Act, therefore, does not allow equipment within 10 feet of high voltage hydro lines. This includes drilling rigs.

The Ontario Ministry of Transportation and Communications (MTC) requires the property owner to obtain a permit prior to constructing a well within certain limits from the boundary (the property limits) of any King's Highways and from the centre of intersections. These permits are available at no charge from MTC District Offices.

## FINANCIAL ASSISTANCE

In the past farmers have received financial assistance from the Ontario Ministry of Agriculture and Food for the construction of new water wells or the improvement of existing wells. Information regarding this financial assistance is available from the Ontario Ministry of Agriculture and Food.

## HIRING A CONTRACTOR

All water-well contractors are required by the Ontario Water Resources Act, (Section 40) to be licensed. A contractor is required to have at least two years experience in the construction of wells or must retain a full-time employee who has had this experience in constructing wells. A copy of regulations respecting well construction in Ontario is

available at Regional Offices of the MOE.

Before the construction of a well begins, it is reasonable (and recommended) to ask to see the contractor's licence and to enter into a written contract with the water-well contractor.

It is not usual for a contractor to guarantee that the well will provide an adequate supply of water for your needs or to guarantee, prior to construction, the quality of the water to be found. Prior to signing the contract, the property owner may wish to question the contractor and obtain his comments on the following factors and upon mutual agreement have a number of them included in the contract. Many of these factors are explained later in the text:

1. What is the price per foot of drilling or boring? Does this price apply to the entire well and does it include casing?
2. What is the price per foot for new steel casing, cement tile or galvanized steel casing and what type will be installed?
3. What is the inside diameter of the steel casing or cement tile?
4. What is the price for pulling the casing or tile if the well must be abandoned?
5. Will the contractor give an estimate of the depth of the completed well and the amount of casing which will be used?
6. At what depth will drilling or boring be stopped if sufficient water is not obtained so that the owner can be reached to authorize further drilling or boring?
7. What is the anticipated price of well development?
8. What will the contractor do if the well water remains sandy or cloudy after it is completed?
9. What will the contractor do if the well cannot be pumped at the required rate?
10. What is the price for chlorinating the well?
11. When will the construction of the well begin?
12. Will the contractor agree to keep working on the well continuously and to complete it as quickly as circumstances allow? Will the completion date be included in the contract?
13. What is the approximate cost of screens, drive shoes, well seals, and air vents?
14. Will a screen be installed if water is encountered in overburden?

15. Does the contractor agree to return and repair the well if necessary, (say within two weeks) after receiving a written complaint?
16. If the contractor installs the pump, how much will the installation costs be?
17. What is the cost of the pumping equipment?
18. What is the price to install low permeability material in the annular space of bored wells?
19. What will the contractor charge to seal off poor quality water?

Considerations when drawing up a contract are included in Appendix C.

## FINAL WELL INSPECTION

Wherever possible, after a well is completed, it should be inspected by the owner before the contractor removes the well construction equipment from the site. It is recommended that you ask the contractor to measure the depth of the well in your presence.

You are also advised to see that the well has been capped, the water in the well chlorinated (Appendix F) and determine when you will be receiving your copy of the water-well record. All of these are required by regulation.

The water-well record is an important document recording construction details of your well and provides the pump installer with vital information to properly equip the well with a pump. We therefore suggest that full and final payment on a well should not be made until this document has been received. A copy of the water-well record form is presented in Appendix B.

## WATER WELLS AND THEIR CONSTRUCTION

There are a series of steps followed in the construction of a well. A well may be dug, bored, drilled or driven. The method used will vary with the geology of the area, accessibility to drilling equipment, depth at which the water-bearing formation is found and the equipment available to the water-well contractor.

As part of the construction, all or part of the well is cased. This involves lining the sides of the well with a material that will prevent the open hole from collapsing and prevent surface water from moving into the well. The water-well contractor is required to follow specific standards established in Regulation 648/70.

Following completion the top of the well must be capped in a secure manner to protect it until the pump is installed.

A comparison of the different well types and their application to different geologic materials (Table 2) is included to assist the individual who wishes to have a well constructed.

### DUG WELLS

Digging a well was the usual method of construction before the development of motor-driven boring or drilling machines. Now, dug wells are used in areas where a dependable supply of gound water exists at shallow depths and in materials which can be excavated by a backhoe or by pick and shovel. Dug wells are seldom more than 30 feet deep and are usually three or more feet in diameter, wide enough for the digger to work conveniently. Because dug wells usually only penetrate the water-bearing formation for a short distance, many of them dry up when the watertable drops. As a result, many old dug wells are being replaced by deeper more reliable drilled and bored wells.

Dug wells are usually cribbed with concrete or vitrified tile. Since they are very susceptible to pollution, the upper eight feet should be set with watertight joints and protected with a cover raised above the ground level.

Old dug wells, still in use as water-supply sources, should be reconstructed to meet modern well standards by having their upper eight feet set with watertight joints and a raised watertight concrete top constructed. This prevents the entrance of polluting material.

TABLE 2. A COMPARISON OF DIFFERENT WELL TYPES AND THEIR APPLICATIONS

| WELL TYPE | SUITABLE GEOLOGIC MATERIALS | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|
| DUG WELLS | OVERBURDEN both low and high yielding materials (gravel, sand, silty, clay) | 1) Does not require special machinery to construct<br>2) Large diameter provides reservoir storage to augment low yields<br>3) Can be constructed in areas of limited access | 1) Labour intensive to construct<br>2) Depth is limited because of caving<br>3) Well failure is common during dry periods because of usually shallow depths |
| BORED WELLS | OVERBURDEN both low and high yielding materials (gravel, sand, silt, clay) | 1) Efficient method of constructing large diameter wells<br>2) Large diameter provides reservoir storage to augment low yields | 1) Depth is limited because of caving, boulders and bedrock |
| DRILLED WELLS | OVERBURDEN AND BEDROCK moderate to high yielding materials (sand, gravel, sandstone, limestone) | 1) Can reach deeper depths than other techniques<br>2) Can penetrate bedrock | 1) Generally small diameter wells with little reservoir storage capacity |
| DRIVEN OR JETTED WELLS (Sand Points) | OVERBURDEN moderate to high yielding materials (sand and gravel) | 1) Simple installation; can be done by hand or machine<br>2) A number of these wells can be hooked into one water-supply system | 1) Small diameter provides little reservoir storage<br>2) Depth is limited; depends on materials in overburden |

BORED WELLS

Bored wells are usually constructed in areas where water is found relatively close to the land surface in overburden materials. For the most part, their construction is limited to materials which are stable and will not cave during excavation.

The average depth of a bored well is under 50 feet and very few extend to depths greater than 100 feet. Common casing diameters of bored wells are 24, 30, and 36 inches. The large diameters of these wells act

as storage reservoirs for use during periods of heavy demand. During periods of low demand, the reservoirs are replenished by ground-water seepage.

The water levels in bored wells are prone to seasonal fluctuations because of the shallowness of the wells. Insufficient quantities of water during long dry periods is a common problem.

Bored wells are usually constructed with a boring rig (Figure 3) by rotating a cylindrical bucket equipped with cutting blades at the bottom. It is similar to the bucket auger used for digging fence-post holes. The bucket is attached to a rotating kelly bar. When full, the bucket is lifted out and the earth is dumped. Boulders often cause trouble in boring and sometimes it is necessary to remove them from the excavation manually.

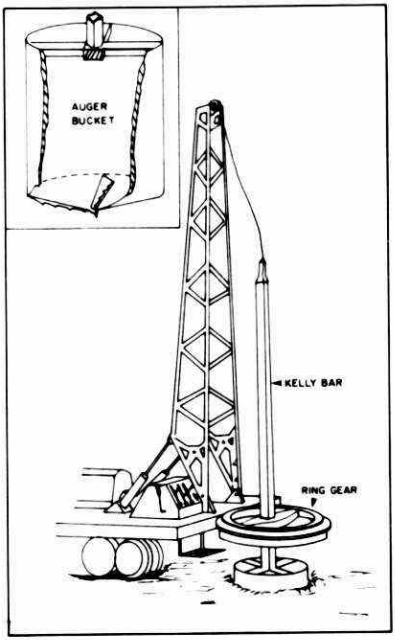


FIGURE 3. BORING RIG.

After water has been reached, well casing is lowered into the hole. The casing is usually cement tile or corrugated galvanized pipe (Figure 4).

Bored wells are usually not equipped with screens but most contractors put a few feet of washed gravel in the bottom of the well and in the annular space around the outside of the lower cased portion to prevent the movement of sand into the well.

The well contractor must fill the annular space between the outside of the casing and the sides of the well from the land surface to a depth of no less than eight feet with cement grout, concrete, bentonite, equivalent commercial slurry, clay slurry or puddled clay. Similarily, all joints in the well casing must be made watertight from the surface to at least eight feet below ground. This is to prevent the movement into

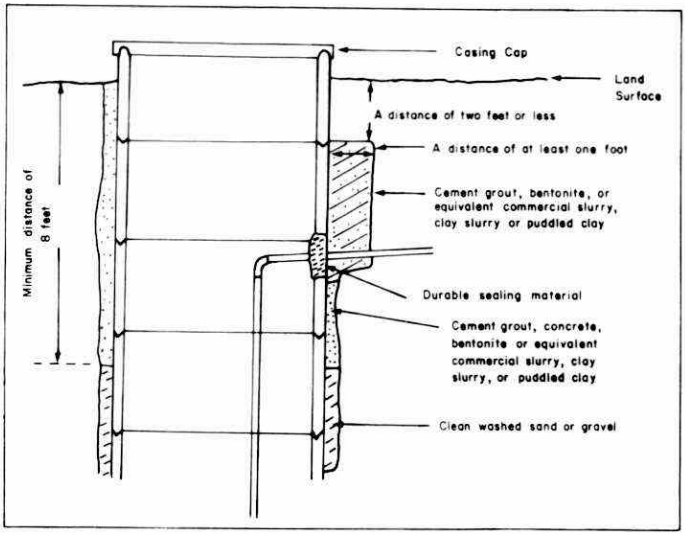
Casing Cap
Land Surface
A distance of two feet or less
A distance of at least one foot
Cement grout, bentonite, or equivalent commercial slurry, clay slurry or puddled clay
Minimum distance of 8 feet
Durable sealing material
Cement grout, concrete, bentonite or equivalent commercial slurry, clay slurry, or puddled clay
Clean washed sand or gravel

FIGURE 4. BORED WELL.

the well of surface and near surface drainage, which may be polluted. Below eight feet the annular space is usually filled with clean, washed, gravel or sand.

The top of the casing should extend at least six inches above the land surface and be covered with a heavy cap or lid to prevent entry of foreign material into the well.

## DRILLED WELLS

Drilled wells can be of any depth from 10 to over 600 feet. In Ontario they are commonly between 50 and 200 feet deep. Because of their depth, these wells are less likely to become contaminated or to be affected seriously by seasonal water-level fluctuations.

Drilled wells require casing in the upper part of the well to prevent the encroachment of loose overburden material and to keep out polluted surface water. If the well is drilled into bedrock, the bedrock portion may not require casing. Casing diameter should be compatible with the pumping equipment. Well casing must be made of new material and meet the

minimum wall-thickness specifications established by the Ministry of the Environment. Although steel pipe is generally used; brass, copper, stainless, plastic and fibreglass can be employed where the corrosiveness of the water reduces the effective life span of steel casing.

Some of the drilling methods used are described below:

## Cable-tool drilling

In cable-tool drilling, the hole is formed by the hammering and cutting action of a heavy punching tool, repeatedly raised and dropped on the bottom of the hole. The hammering breaks the formation into fragments which are mixed with water and removed at intervals by a bailer or sand pump. When cable-tool drilling is used, the casing is driven down as the hole is drilled. Figure 5(a) illustrates a cable-tool drilling rig.

## Conventional rotary drilling

Rotary well drilling is done by rotating a drilling bit that chops and cuts the formation into small particles. These drill cuttings are then washed out of the hole and the hole kept open by circulating drilling mud which is a mixture of a commercial drilling mud and water. The mud is pumped down the drill pipe, through the bit and moves between the drill pipe and the open hole to the surface. Well casing is installed into the excavation as the hole is being completed. Figure 5(b) illustrates this drilling method.

## Reverse circulating rotary method

This method is similar to rotary drilling, except the flow of the drilling mud is reversed. Mud moves from the surface to the drilling bit and through the centre of the drilling bit and drill rods up to the surface. This method is primarily used for larger diameter wells (18 to 60 inches).

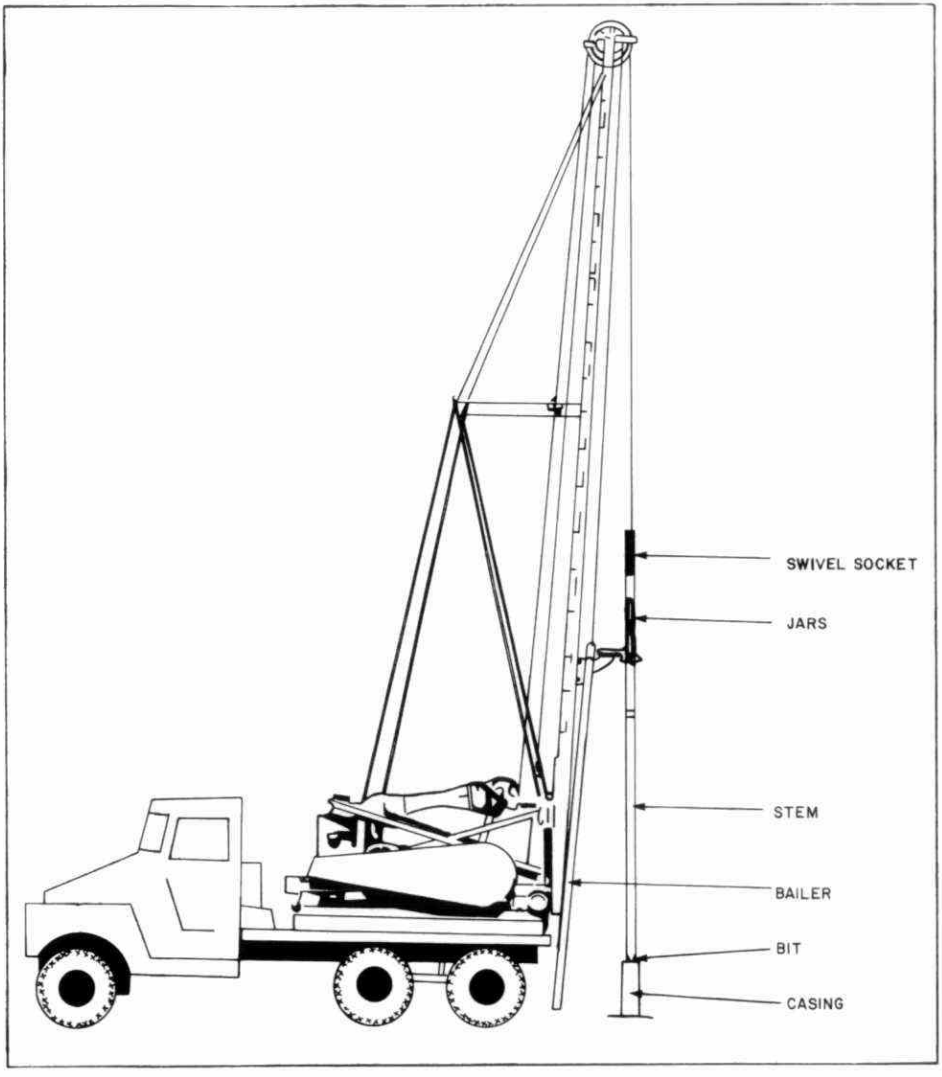


FIGURE 5a. CABLE TOOL RIG.

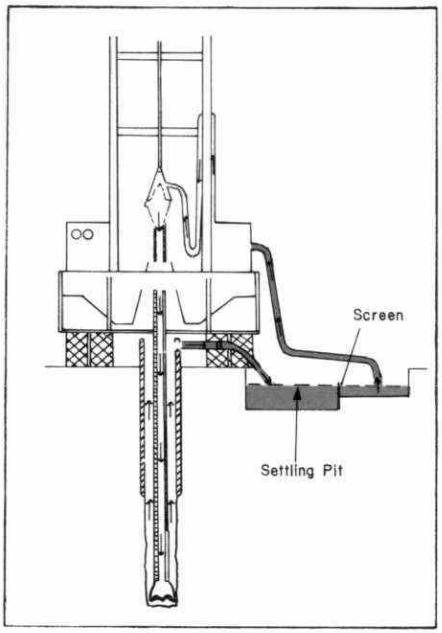


FIGURE 5b. CONVENTIONAL ROTARY DRILLING SYSTEM.

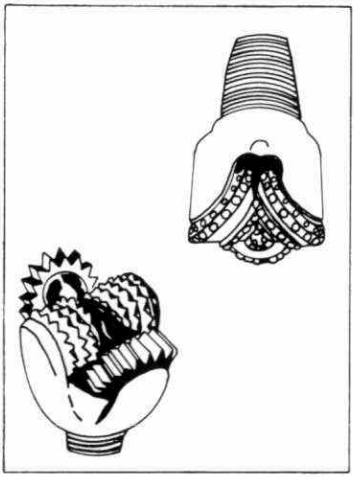

FIGURE 5c. ROTARY BITS.

Air rotary method

This method is the same as the conventional rotary drilling methods, except compressed air is used instead of drilling mud in removing the cuttings. This method is used mainly in bedrock and hard clay. Figure 5(c) illustrates a cone type rotary drill bit.

Down-the-hole hammer method

The down-the-hole-hammer method utilizes the percussion effect of cable tool drilling and the rotary action of rotary drilling. Cuttings are forced out of the hole using compressed air. It is the fastest method of penetration in hard rock formations; the penetration results from air piston blows transmitted directly to the bit.

Diamond drilling method

The diamond drill is used mainly in hard bedrock. The drill bit has diamonds set in the cutting surface. The cuttings are removed by a jet of water which also cools the bit. Most diamond drilled wells are two inches or less in diameter.

Jetted wells

This well is made by forcing a high-speed jet of water into the ground. Jetting may be done by using drill bits to aid the cutting or by sinking in casing that is to remain after the well is completed, or by sinking in self-jetting well points.

WELL POINTS

Where the watertable in a water-bearing sand and gravel is found within 15 feet of the surface and the soil is soft and relatively free of stones, a well point or sandpoint (Figure 6) may be driven directly into the ground.

A well point is a well screen threaded to metal riser pipe. The tip of the well screen will act as the drilling bit. When in place the riser

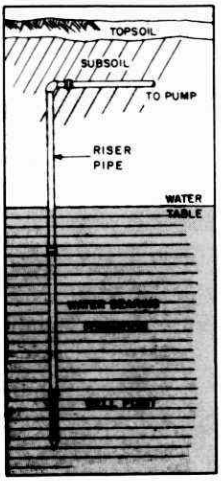


FIGURE 6. WELL POINT.

pipe can be connected directly to the pump. Well points usually vary from one to two inches in diameter and from two to eight feet in length.

## SPRINGS AND SEEPS

Springs and seeps occur where the watertable intersects the land surface or where a confined aquifer outlets to the surface. A spring is a distinct flow of water, while a seep is a wet or marshy area. Springs are common in areas of strong topographic relief such as along the Niagara Escarpment and Oak Ridges Moraine. Seeps are common to areas of low relief.

Springs and seeps, capable of yielding water of a quantity and quality sufficient to meet domestic needs, are present in many areas of the Province. Considerable discretion should be used however, in developing such supplies, in that they are easily contaminated.

As a general rule, springs which experience a flow change immediately after a rain or which become muddy, should not be used for a water supply. The infiltrating precipitation, which contributes to the flow of such springs, may have only moved a short distance through the subsurface before discharging. This distance is usually insufficient to remove (filter out) bacteria and other organisms which are harmful to health.

Springs which "dry up" during the summer months, should be treated as unreliable sources and should only be used to supplement an alternative supply.

Water samples should be collected from all springs and seeps which are considered for use. These samples should be examined in the same manner as those for new water wells. Continuous chlorination is highly recommended for spring and seep supplies. Care should be taken to keep the supply sanitary. All surface water should be diverted away from the supply, animals should be kept away from the area, and any structure used to house the spring should be water tight and have a tight-fitting cover.

Making works or installing equipment for collecting a spring is deemed to be the constructing of a well in Ontario and therefore should be done in compliance with well construction regulations.

## SCREENS

Once the drilling is completed, the contractor should examine the cuttings from the water-bearing formation (in overburden wells) and decided if a screen is needed. A well screen (Figure 7) is a pipe-shaped device, usually commercially manufactured, having small openings that permit the easy entry of water into the well while keeping out the fine-grained materials. Fine-grained materials can plug the plumbing fixtures and cause excessive wear of the pump. If a well is drilled into coarse sand or gravel, a screen may not be needed. Wells terminating in bedrock may not need screens because the cracks and fissures from which water is obtained contain few fine particles that can plug the well. The proper screen will allow water to enter the well with a minimum of resistance, thus increasing the well's effectiveness and yield.

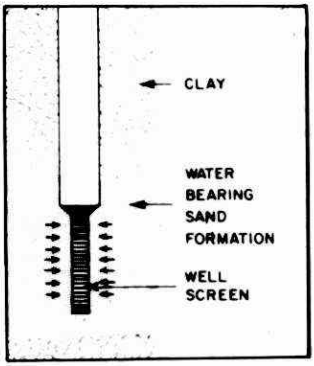

FIGURE 7. WELL SCREEN AND SLOT.

The size of opening in the screen depends on the particle size of the sand and gravel. Most screen manufacturers will analyse the particle size of the aquifer material and recommend an appropriate slot-size for the screen. The slot openings are sized so that about 60 percent of the finer materials surrounding the screen can be kept out during development. The remaining 40 percent of the coarser sand or gravel will form a

natural filter around the screen. The slot number of the screen represents the width of the opening in thousands of an inch. For example, No.6 slot means that the width of the slot is six one thousands (0.006) of an inch.

Two types of screens are commonly used in domestic wells, the slotted-pipe screen and the continuous-slot. The slotted-pipe screen has parallel slots cut directly into the casing. Such casings are available from manufacturers or can be made by cutting a casing with a saw, a cutting torch or a casing perforator. This type of screen is suitable only for coarse sand and gravel formations, since the slots cannot be spaced closely enough to control fine or medium sand. The slotted casings are usually not made of corrosion resistant materials and will tend to corrode faster than the continuous-slot screens. This type of screen is usually not recommended.

The continuous-slot screen is commercially made by winding a flattened wire in a spiral around a circular framework of rods. The slots can be made to vary in width from 0.006 to 0.15 of an inch. This type of screen provides a larger intake area than the slotted-pipe screen. The screen is usually made of a corrosion-resistant material such as stainless steel or bronze.

Plastic and fibreglass screens have become available recently. They are less expensive than stainless steel, are corrosion resistant and are relatively easy to install.

## Installation of screens

The most common method of installing a screen is called the pull-back method. The well casing is sunk to the full depth of the well and the well screen is placed at the bottom of the well inside the casing. The casing is then pulled back a distance equivalent to the length of the screen. The top of the screen is fitted with a lead or neoprene packer, to make a sand-tight seal between the top of the screen and the well casing.

## Developing the well

Well development (Figure 8) is a step used after the installation of a screen to increase the efficiency of a well. In developing, water or

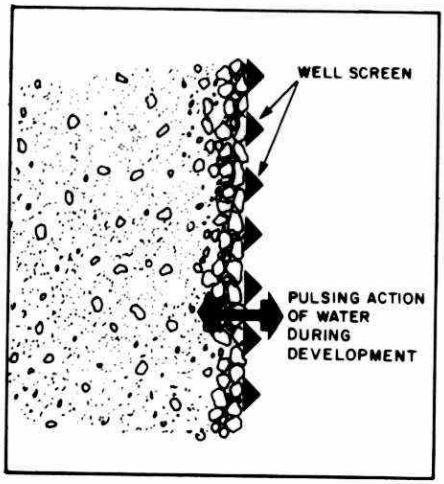


FIGURE 8. WELL DEVELOPMENT.

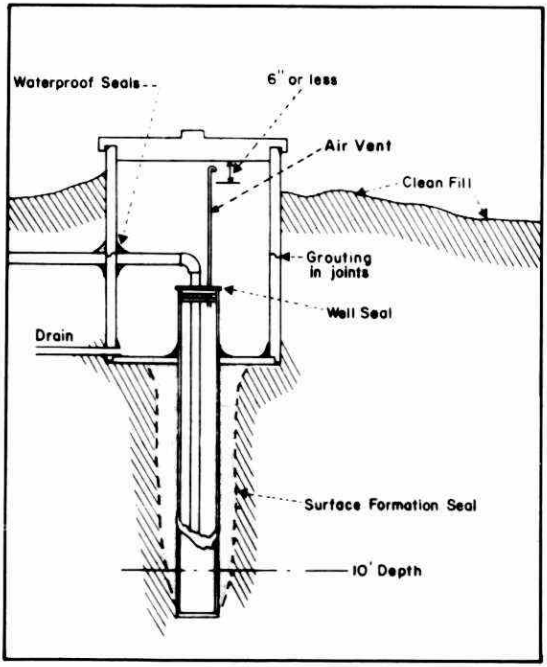


FIGURE 9. CASING SEAL AND WELL PIT CONSTRUCTION.

air is forced or surged back and forth through the well screen dislodging the fine particles around it. These particles are then pumped or bailed out of the well.

Development should continue until fine particles no longer appear in the bailed water, suggesting that the formation around the screen has stabilized. The envelope of coarser sand left behind, around the screen, forms a natural filter.

Water jets, surging blocks, plungers or air compressors are used to develop wells. Proper development can correct the damage done to the water-bearing formation during drilling, by removing leftover debris and drilling mud. It unclogs the screen and the sand formation around it to give a better yield of sand-free water.

## SURFACE FORMATION SEAL

To prevent surface water which may be polluted from moving into a well, a water-well contractor is required to seal the upper part of the space between the outside of the casing and the sides of most types of wells. This seal (Figure 9) should be of a low permeability material such as cement grout, concrete, bentonite or equivalent slurry, or clay slurry. To facilitate the placement of this material, the upper portion of the well is drilled at least two inches larger in diameter than the well casing.

Driven wells and small-diameter, diamond-drilled wells also require a surface seal. On these wells the seal is usually installed by packing the upper outside area with low permeable material after the drilling has been completed.

## WELL SEAL

When a pumping system is connected to a well through the top of the casing, a commercial well seal (Figure 10) must be used to prevent surface water or foreign material from entering the well. A common type of well seal consists of a rubber disk sandwiched between two metal plates. The rubber and metal plates are made with holes to accommodate pump pipes and an air vent. The plates and rubber disk are held together by bolts. When the bolts are tightened the rubber is squeezed against the pump pipes, the vent and the side of the casing to make a watertight seal.

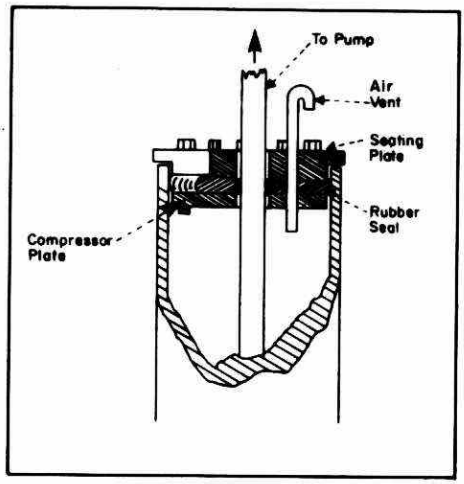


FIGURE 10. SEAL AND AIR VENT.

AIR VENT

An air vent (Figure 10) is necessary to equalize air pressure between the inside of the casing and the atmosphere and to release noxious or explosive gases. In a well pit, the vent extends vertically from the casing to within six inches or less below the top of the pit. It is shielded to prevent the entry of foreign material into the well. Where a well pit does not exist, the vent should extend a minimum of twelve inches above the level of the land surface and the opening shielded to prevent entry of foreign material. The vent should be removable, to provide access for water-level measurement.

WELL PITS

Well pits (Figure 9) are shallow pits constructed around the top of a well to allow for easy access into wells for inspection, maintenance and repair. To prevent contamination of a well, the pit must be constructed so that surface water does not enter. The pit should extend from several inches above, to a minimum of four feet below ground-level. It should be covered with a removable top. If concrete tiles are used in the construc-

tion of the pit, all joints should be grouted and the floor well-drained. The top of the well casing should rise several inches above the floor. All holes made through the sides of the pit to install pump pipes should be sealed with a waterproof material. Well pits are only recommended in well-drained areas. Pitless adaptors are recommended as a superior method to make underground connections to wells.

## PITLESS ADAPTOR

Pitless adaptors (Figure 11) are widely used to-day to permanently install the horizontal water discharge pipe leading away from the well. A specially designed connector provides a water-tight seal through the side of the well casing below frost level and also permits the easy removal of the vertical water discharge pipe located inside the casing. This provides easy access for periodic well or pump repairs. On these installations the casing is usually left 8 inches above ground level.

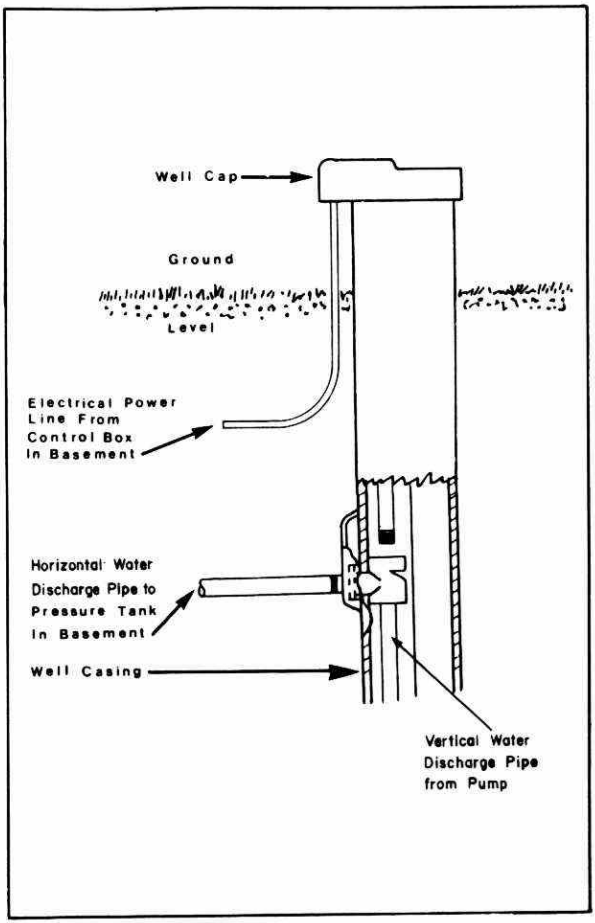


FIGURE 11. PITLESS ADAPTOR.

## WATER DISTRIBUTION SYSTEM

With the completion of the well, consideration should be given to the water distribution system, namely the pump, motor, pressure tank, controls and plumbing (Figure 12). The water distribution system supplies water to the user at a near constant rate and pressure. Such a system should be carefully planned to ensure that both immediate and foreseable future needs are satisfied. The following sections deal with the components of the water distribution system, the considerations which should be made in the selection of these components and some of the common problems which may occur and result in the system's failure.

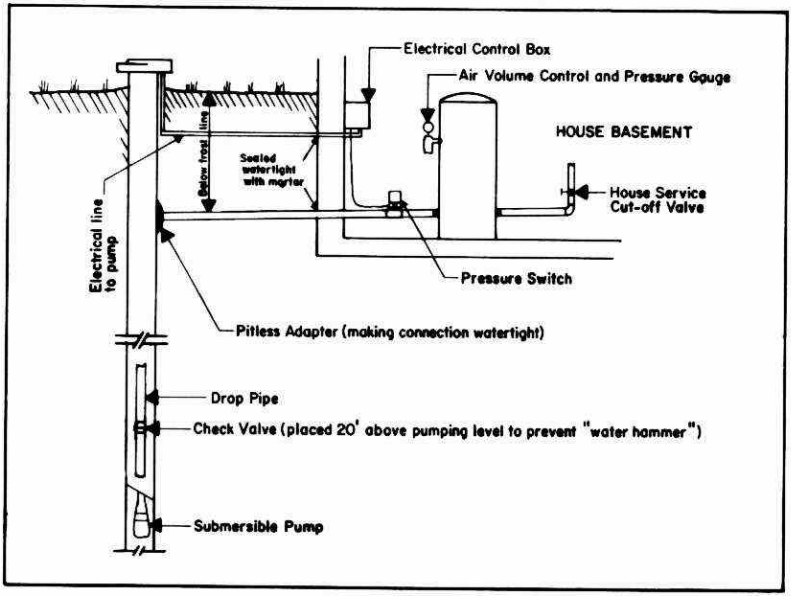
Electrical Control Box
Air Volume Control and Pressure Gauge
HOUSE BASEMENT
Below frost line
Sealed watertight with mortar
House Service Cut-off Valve
Electrical line to pump
Pressure Switch
Pitless Adapter (making connection watertight)
Drop Pipe
Check Valve (placed 20' above pumping level to prevent "water hammer")
Submersible Pump

FIGURE 12. COMPLETE WATER DISTRIBUTION SYSTEM.

### PUMPS

The basic purpose of the pump is to lift water from the well and to distribute it to where it will be used. This is accomplished by creating an increased pressure at the point at which the water is discharged and reduced pressure at the point of intake.

Pump selection

There are many different types and sizes of pumps. The type of pump to be used in a particular situation is dependent on the following considerations:

1. the safe (rated) yield of the well,
2. the inside diameter and plumbness of the well,
3. the pumping level,
4. the average discharge pressure required,
5. the capacity required, and
6. the availability of servicing from the equipment supply dealer.

The safe yield of the well is the amount of water that the well will supply during a sustained period of usage without drawing the water level down to the level of the pump intake causing the pump to break suction. The safe yield varies considerably from well to well. Upon well completion, the drilling contractor will recommend a pumping rate and a depth from surface at which the pump intake should be set. The pump should have a capacity equal to or less than the recommended pump rate. A pump which has a higher capacity than the yield, will draw the water level down to the intake causing the pump to break suction. This may result in the overheating of the pump and subsequent damage.

The inside diameter of the well can dictate the size of the pump, drop (intake) pipe(s) and foot valve which can be installed. This dimension is specified on the water-well record submitted by the drilling contractor.

The well straightness or plumbness should also be checked, in that certain types of pumps (i.e. submersibles) cannot be installed where the well is crooked.

The pumping level is the vertical distance from the ground surface to the water level during the operation of the pump. Following the completion of the well, the drilling contractor is required to conduct a pumping or bailing test during which the drop in water level is recorded at set intervals of time. The initial measurement just prior to pumping is the static water level. The final measurement during or after pumping, is the pumping level. The difference is known as the drawdown. Most wells will have some drawdown after the pump is activated.

The practical maximum height that a pump will lift water (difference

between the pump elevation and the pumping level) through suction is 22 feet. The 22-foot limit on suction lift is the cut-off point between shallow-well pumps and deep-well pumps. If the pumping level is 20 feet and the pump is to be installed in a location which is 10 feet higher than the top of the well, the total lift required is 30 feet. This would mean that a deep-well pump is necessary in this situation.

The average discharge pressure is the pressure at which water discharges from the pump at the outlet. This value is specified in pounds per square inch. The average discharge pressure required is the upper intake pressure of the pressure tank, also specified as the pressure at which the cut-out switch is activated. For most tanks this is 40-50 lbs./sq. inch.

In some instances the pressure tank is installed away from the pump and at a higher elevation. Where this occurs additional discharge pressure will be required to make up for the higher elevation and to compensate for friction loss in the plumbing (pressure needed to push water through the pipes, etc.). Each pound per square inch of pressure added to the discharge at the pump will raise water an additional 2.31 feet (also known as feet of head). Most reputable water-supply equipment dealers have tables from which the friction loss from the plumbing can be calculated.

The capacity required is the water demand during periods of peak usage (expressed in gallons per hour). This rate is fixed by the well capacity (the rate at which the well will yield water). In cases where the well capacity is low, a large pressure tank will be necessary to meet the capacity requirements of the home during periods of peak usage.

Where the well yield is ample, the capacity required can be roughly estimated by counting the maximum number of fixtures and water outlets in the house which will be used at one time and multiplying by the flow rate for each. The flow rate is generally between 1 and 5 gallons per minute. Water-supply equipment dealers have tables from which the flow rate per fixture can be determined. For example, if it is anticipated that at least 4 faucets will be operated at one time (dishwasher, toilet, outdoor faucet and washing machine), the peak demand may be 4 faucets X 3 gallons per minute = 12 gallons per minute. If this requirement is maintained for one hour the capacity required is 12 gallons per minute X 60 minutes per hour = 720 gallons per hour. The water-supply system must

therefore be capable of providing 720 gallons per hour of water at a constant pressure for short periods of time.

A pump can now be selected which adequately meets the needs of the well owner. An additional consideration which should be made at this time is the availability of servicing in case of pump failure. For instance, where is the nearest dealer who will service the pump?

## Pump installation

Pump installation procedures vary considerably with the type of pump selected. Drilling contractors will usually specify whether or not they can install a pump, others will subcontract such installations to plumbers or, in some instances, the well owner will either have to find a pump installer or plumber, or install the pump himself. Many pump manufacturers have installation booklets for the "do-it-yourselfer". These booklets are generally of a technical nature and are directed towards an individual with electrical and plumbing experience.

A number of considerations are common to most pump installations. These include:

1. proper pump housing and ventilation,
2. proper pump maintenance and lubrication schedule,
3. the provision of over-load protection, in either the form of fuses or circuit breakers,
4. proper electrical wire sizes and connections, and
5. the provision of lightening protection especially in the case of submersible pumps.

## Shallow well pumps

When a shallow-well pump (Figure 13) starts, it exhausts air from the pump drop pipe. A vacuum is created and the atmospheric pressure on the water outside the drop pipe forces water to the top of the drop pipe. The maximum practical lift of a shallow-well pump at sea level is 22 feet. At an elevation above sea level, the air is less dense resulting in lower atmospheric pressure outside the drop pipe, reducing the maximum suction lift.

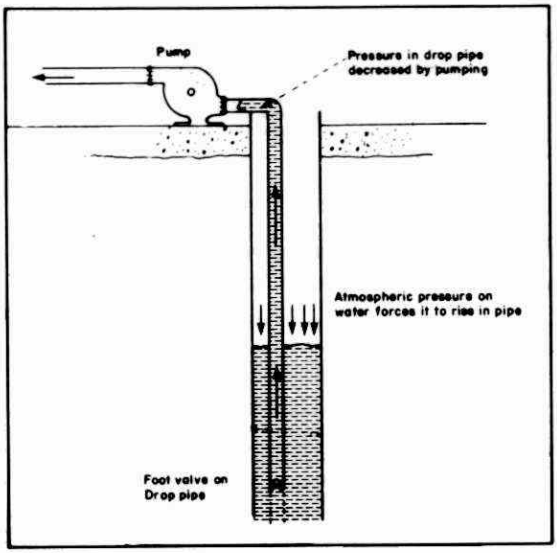
Pump
Pressure in drop pipe decreased by pumping
Atmospheric pressure on water forces it to rise in pipe
Foot valve on Drop pipe

FIGURE 13. SHALLOW WELL PUMP - PUMP SUCTION PRINCIPLE.

Three common types of shallow-well pumps are: 1) reciprocating (piston), 2) centrifugal and 3) centrifugal jet.

1. Reciprocating (piston) Pump - A vacuum is created by the movement of a piston inside a cylinder. Continuous repetition of the forward and reverse strokes results in a steady flow of water into the discharge pipe.

2. Centrifugal Pump - This pump resembles a snail-like assembly. Water is propelled by rotating impellers forcing the water through the assembly. The pump casing and the suction line must be kept full of water (primed) in order for the pump to operate.

3. Centrifugal-jet Pump - This pump is similar to the centrifugal pump but the pressure (suction) in the pump is increased by forcing water through narrow jets. A smooth flow of water is supplied to the water pressure system but the pump must be filled with water (primed) in order to operate.

Deep well pumps

1. Reciprocating (piston) Pump - This pump (Figure 14) consists of either a motor or a hand powered mechanism located at the top of the well

and a cylinder installed in the well casing.

The motor or hand lever moves a piston in the cylinder up-and-down supplying a constant volume of water to the water-distribution system. This type of well can supply water from depths of 400 to 500 feet.

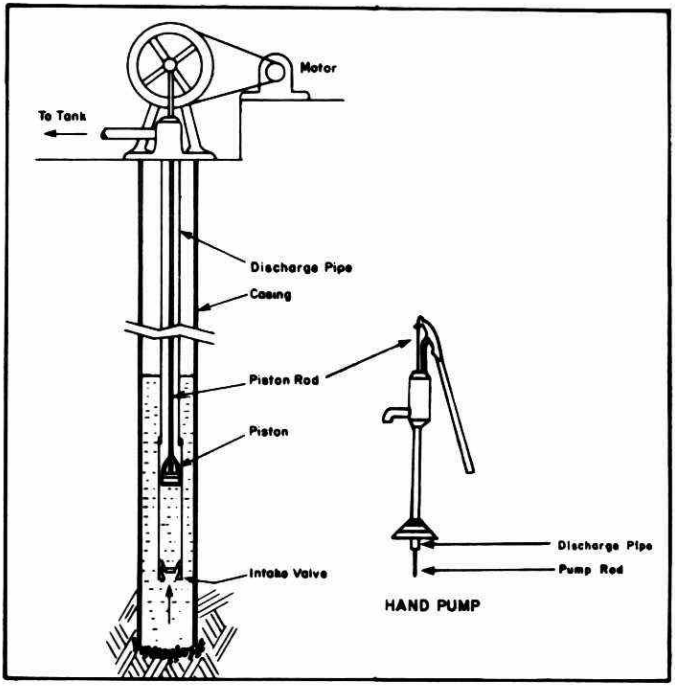


FIGURE 14. DEEP WELL PISTON PUMPS.

2. Deep Well Jet Pump - This pump (Figure 15a) consists of a pump unit at ground level with an ejector assembly (Figure 15b) down in the well casing.

A drive pipe and a suction pipe run from the pump to the ejector assembly in the well. A special version is also available for small diameter wells (2 inch, 2½ inch and 3 inch) whereby a packer type ejector is used with only a suction line running from the top of the casing to the ejector.

A deep well jet pump can deliver water efficiently from about 100 feet. Greater depths are possible at the expense of reduced

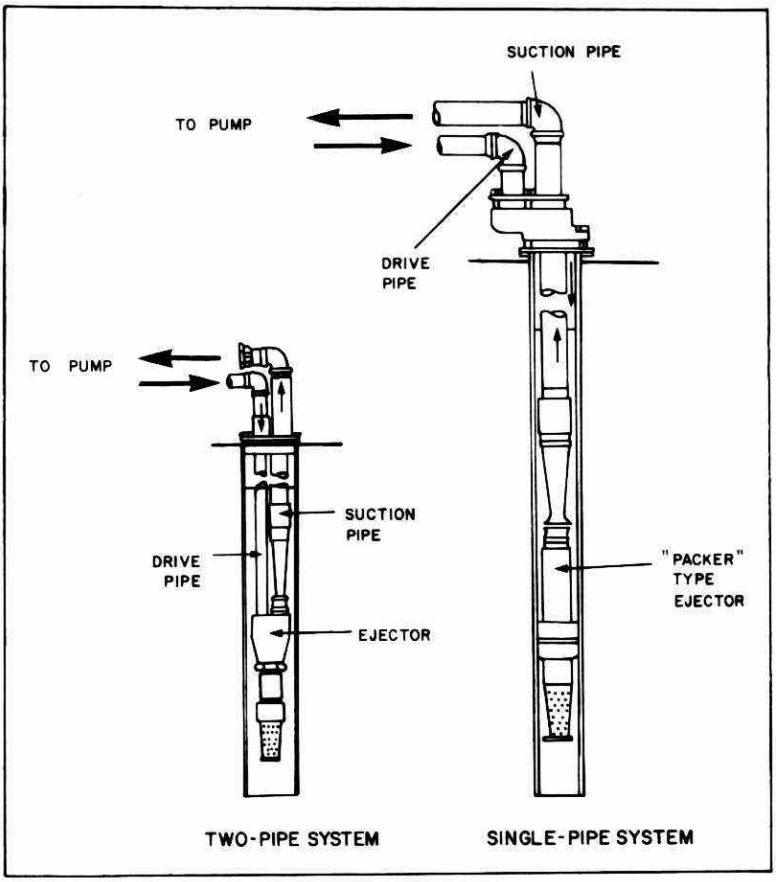


FIGURE 15a. DEEP WELL JET PUMP SYSTEM.

efficiency (at 100 feet, 75% of the water pumped is returned to the ejector).

3. Submersible Pump - The entire assembly of a submersible pump, (Figure 16) including the motor, is installed in the well casing below water level. The pump is connected to the surface by a discharge pipe and by a waterproof electric cable that leads to the motor. Submersible pumps can deliver water from depths to 1000 feet. This is the most common type of pump used in deep wells in Ontario. It is not advisable to install a submersible pump if sand or gas are present in the water. The sand will abrade parts in the pump shortening its life. If gas is present in the water it may cause the pump to lose its prime.

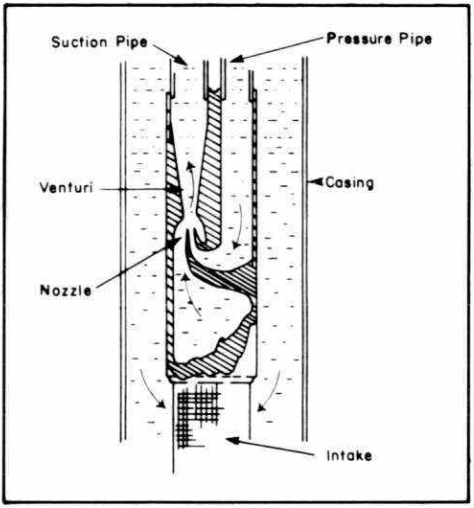


FIGURE 15(b). DEEP WELL EJECTOR ASSEMBLY

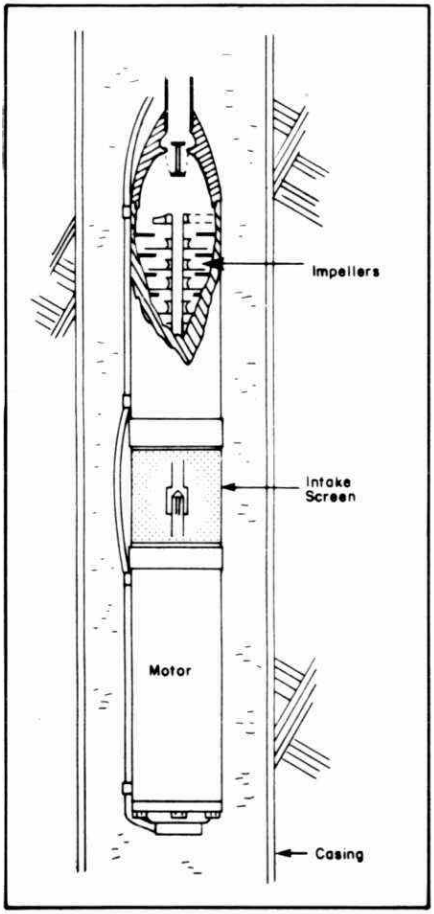


FIGURE 16. SUBMERSIBLE PUMP.

Listed below are the advantages and disadvantages of three common pumps used in domestic wells.

| | ADVANTAGE | DISADVANTAGE |
|---|---|---|
| **Reciprocating Pump** | | |
| | i dependable, low cost, can be used in small diameter wells,<br>ii yields water at a constant rate and a high pressure,<br>iii easy to prime, and<br>iv can pump small amounts of sand. | i noisy with vibrations<br>ii pulsating discharge |
| **Jet Pump** | | |
| | i low cost,<br>ii high capacity at low total head,<br>iii can be converted to deep-well jet,<br>iv easy to service because of few moving parts,<br>v high pressure can be acquired with multistage units,<br>vi can be offset from well and<br>vii easy to install | i can't handle air in system,<br>ii needs large pipes,<br>iii difficult to prime if there is a leak in line,<br>iv requires high pressure pipe for multistage jet,<br>v easily damaged by sandy water |
| **Submersible Pump** | | |
| | i very efficient, smooth, even flow<br>ii has an excellent range in capacity and pressure,<br>iii long lines cause few problems,<br>iv constant capacity,<br>v no noise,<br>vi can be used for shallow or deep well and<br>vii free from freezing. | i loss of prime can cause damage to motor,<br>ii not always easy to service and is expensive,<br>iii sand in water will wear pump parts,<br>iv three-inch diameter is smallest available,<br>v if screen becomes encrusted and flow is impaired the motor may burn out, and<br>vi well must be plumb and free from obstructions. |

## MOTOR AND ELECTRICAL SYSTEM

The power source which drives the pump motor is usually electricity, but pump can be operated by propane gas, gasoline and wind. Hand-operated pumps are still sold and in use in areas of Ontario where there is no electricity or the water requirements are limited. The proper type and size of motor needed to meet specific requirements for a particular pump are supplied by the pump manufacturer. The suggested maintenance requirements should be followed closely. Electrical problems can largely be avoided through the initial installation of adequate wiring and by

continuous protection of this wiring. Protection is needed from damage due to overloading and from lightning. Lightning arrestors, proper grounding, and adequate fuses are all necessary.

## PRESSURE TANK

The hydro-pneumatic pressure tank acts as both a storage reservoir and a means of pressurizing a water-supply system. It is generally included as a component of the system to provide adequate water storage under pressure and thus eliminate the necessity of activating the pump each time a faucet is opened.

The pressure tank operates between two pressure-switch settings. When the pressure in the tank drops to the lower pressure setting, the pump is activated and water is forced into the tank. This compresses the air trapped in the top of the tank until the pressure in the tank reaches the upper pressure setting. When this occurs a cut-out switch is activated and the pumping stops. When a faucet or valve is opened, water is forced through the pipes by the pressure in the tank. When the pressure falls below a certain level, the pump is switched on and the cycle is repeated.

The pressure tank will supply about 20 percent of its capacity before the pump is activated. This is important for wells which have a low capacity. A large tank can be installed which will provide sufficient water during periods of peak usage.

### Air volume control

In that air is partially soluble in water, the air in a pressure tank will gradually dissolve, "water-logging" the tank, and resulting in a loss in pressure. There are three methods of controlling air in the pressure-tank.

1. Air volume control: This is a valve fitted directly on the pressure tank which depending upon the water level and system pressure, either bleeds air from the tank or allows air to enter.

2. Tank float: This device prevents tank air from being absorbed by the water by separating the two. It consists of a circular float which rides on the water in the tank. Some designs have a special edge which rubs against the tank walls, thereby improving the seal. Some air will be dissolved over a period of time, therefore, tanks equipped with floats need to be recharged every few years.

3. Diaphragm tanks: This is a tank equipped with an elastic diaphragm which separates the air from the water. As the water level rises and falls in the tank, the air chamber contracts and expands accordingly.

Pressure switch

The operation of a water system is controlled by the pressure switch which automatically starts or stops a pump at specified tank pressures. The switch is pre-set at the factory and is usually set to activate at a minimum pressure or 20 pounds per square inch and a maximum pressure of 40 pounds per square inch.

## PROBLEMS WITH WELL WATER SUPPLIES

Water-supply problems can be divided into two main categories: equipment failure and well failure. Most water-supply equipment dealers will provide, free of charge, technical information pamphlets which provide "trouble shooting information" on water-supply equipment. In addition, it is a common practice to include "Operating Instructions and Repair Parts List" manuals with new equipment. These guides should be consulted when equipment failure occurs, as many of the common problems can be corrected by such things as replacing a blown fuse, adjusting pressure switches, or other simple maintenance operations. Well failure problems are discussed below.

### WELL FAILURE

#### Natural lowering of the watertable

Water levels in many dug or bored wells are known to fluctuate several feet due to climatic conditions. Ground-water levels in these wells usually reach maximum levels in April or May and then gradually decline until the latter part of September or the beginning of October. When constructing a dug or bored well, it is important that the contractor extends the well far enough below the watertable to assure an adequate water supply during periods when the water level declines.

#### Artificial interference

The water level in most wells can be lowered artificially by the pumping of a nearby high capacity well. This is known as artificial interference. When a well is pumped, the water in the immediate area of the well is lowered. The distance that the water level is lowered is called the drawdown. The drawdown produces a decline in the water level around the well that resembles a cone and is therefore called a cone of depression. The size and the shape of the cone depends on the conditions of the water-bearing formation and the rate of pumping.

An example of well interference is illustrated in Figure 17. Well A, as a result of pumpage, lowered the original watertable to the level

illustrated. With the onset of pumpage in Well B, the deeper of the two wells, the water level has been lowered below that of the intake for Well A. This has resulted in Well A "going dry".

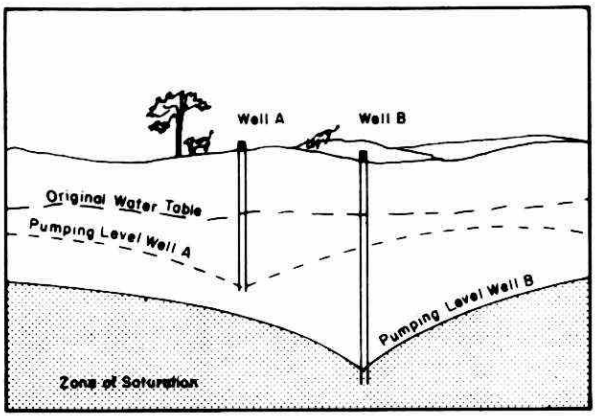


FIGURE 17. CONE OF DEPRESSION.

The construction of sewers, drainage ditches and road cuts occasionally causes interference with nearby shallow wells.

Section 37 of the Ontario Water Resources Act, is used to restore supplies due to interference as a result of water taking under a Permit issued by the MOE and activities such as road, sewer and water-main construction. Where the interference is permanent, the restoration of supplies will be required of the party causing interference. Where interference is deemed to be temporary, an alternate supply for the duration of the inteference will be required.

In situations, where the water level in your well has been lowered and you suspect that this is caused by artificial interference, you should contact the Ministry of the Environment Regional Office. The Regional Office will conduct an investigation to establish the source of the interference, and will act to have the situation addressed.

## Plugged casings

During well contruction, the contractor may encounter water-bearing formations containing clay, silt, or very fine-grained sand (quicksand).

These materials are able to pass through the finest screen, partially filling the screen and slowing the movement of water into the well thus reducing the well yield. The fine-grained particles can move into the intake of a pump causing excessive wear of the moving parts. The water pipes and pressure tank may also become plugged.

If silt or quicksand is encountered during construction, the contractor may advise the owner to deepen the well until another suitable water-bearing formation is found, or to drill in another location.

The most common cause of sand entering the well is the improper selection of a slot size for the well screen. An excessively coarse or poorly sorted gravel pack may also allow sand to enter the well.

The best way of handling this problem is to give consideration to the sand particle size before well screen or gravel pack selection and installation. A competent well contractor will do this as part of the well installation package.

Another source of this problem is inadequate well development. This can be rectified by having a contractor properly develop the well (see section on Developing the Well). Although this is ideally done as part of the installation package, it is also possible to have an existing well rehabilitated.

In established wells, the passage of sand may indicate a corroded screen. Where this is the case, a new screen with a smaller slot size can often be telescoped down the existing well. The new screen and/or casing should be of the same type of metal as the existing ones to prevent electrolytic corrosion (discussed in next section).

Encrustation of well screens

A well screen can sometimes be plugged by deposits of materials such as magnesium or calcium carbonates, hydrated oxides or hydroxides, iron, or deposits of slime produced by iron bacteria. These deposits cause encrustation, and result in a decrease in well yield.

Because the well screen is buried from sight, it often receives no attention until the well yield has been reduced appreciably. Encrustation occurs slowly over a long period of time.

Ground water carries in solution, a variety of minerals and gases including calcium and magnesium carbonate and carbon dioxide. The amount

of calcium and magnesium carbonate that water can carry depends on the amount of carbon dioxide dissolved in the water. When a well is pumped a pressure difference (drop in pressure) is created between the inside of the well and the water-bearing formation. This causes some of the carbon dioxide to be released from the water and the minerals to precipitate out of solution and to be deposited in the voids around the well and openings in the screen.

Encrustation can be reduced by lowering the pumping rate as much as possible so that the velocity of the water entering the well is reduced and a reduction in pressure gradient (pressure difference between the inside the casing and the surroundings). Proper development of the well (see section on Developing the Well) increases the formation permeability around the well which in turn acts to reduce the pressure gradient.

Hydrochloric acid is used to remove the encrustations of magnesium, calcium and iron compounds from a well screen. Sometimes the contractor pulls the screen from the well to acidize or replace it. This is a difficult procedure and it is common to just add the hydrochloric acid directly down the well casing. You should not attempt to acidize your own well because of the danger in handling strong acid solutions. A strong concentration (Appendix F) of chlorine can be used to remove iron bacteria slime-deposits from the well.

It is a good idea to periodically check the performance of the well. This is done by pumping the well at a set pumping rate for a certain interval of time( one hour, two hours, etc.). The difference of the levels of water in the well at the start of pumping and at the end is called the drawdown. If the drawdown has noticably increased since the last time this performance check was taken, the well may have become encrusted. It is a good idea to do a drawdown test when the well is first put into service. This test is routinely conducted by the contractor and the results are included on the well record.

## Corrosion of well casing and screens

Well water is often corrosive and can chemically attack the casing and screen. Four common chemical corrosion processes are: 1) direct chemical, 2) dezincification, c) electrolytic and 3) bacterial. The destruction of the casing or screen by any of these processes will cause well failure.

1. Direct chemical corrosion will cause the screen slots to enlarge two to ten times the size of the original slots. Fine-grained particles originally held out by the screen will then move into the well. The principal source of direct chemical corrosion in ground water is acidity. Acidity is caused by the reaction of $CO_2$ and/or $H_2S$ (both from microbiological activity in the subsurface) and water. In addition, precipitation may be mildly acidic due to the presence in the atmosphere of acid-forming compounds. Fortunately, in southern Ontario, the high carbonate content of the overburden and bedrock acts to neutralize the acid precipitation. This is not the case in norther Ontario, where ground water is often acidic.

2. Dezincification consists in the removal of one of the metals in an alloy leaving the screen in its original shape but in a weakened, spongy form. Dezincification results from the electro-chemical difference in potential between the metals in the alloy.

3. Electrolytic corrosion can result when a screen and its connections are made of two different metals. These metals act like a galvanic cell (battery). One metal acts as the anode and another the cathode. A current is set up between the two metals with the anode becoming corroded and the cathode being protected.

4. Bacterial corrosion References to bacterial corrosion often give the incorrect impression that the bacteria attack metals directly. The bacteria are able to change some of the dissolved materials in ground water so that more rapid corrosion of casing or screens occurs from these; for example, sulphate-reducing bacteria may reduce calcium sulphate to hydrogen sulphide and sulphuric acid. Each of these compounds make water more corrosive and thus speeds up the corrosion of metals in particular iron and steel.

Little can be done with respect to corrosion once the casing and screen have been installed, in that the corroded casing and well screen will need to be replaced. Preventative "foresight" is the best approach to this problem. For instance:

1. establish from well contractors, plumbers and neighbours whether corrosion problems are common in your area.

2. if so, have your well contractor install casing and a screen which is less likely to be affected by such corrosion.

## FLOWING WELLS

Flowing artesian conditions are present in many areas in Ontario. Wells encountering water-bearing formations with such conditions will flow either continuously or periodically during the year, depending on the pressure in the aquifer. Most flowing wells produce more water than is required for household needs. The excess water is usually discharged onto the ground surface. The Ministry of the Environment, in order to discourage such waste and promote water conservation, requires that flowing wells be constructed in such a manner as to ensure that the flow of water from the well can be controlled. This is commonly achieved by cementing a slightly larger diameter casing (than that of the finished well) into the upper portion of the well prior to drilling into the artesian aquifer. A valve is then attached to the casing which will regulate the flow rate.

A bulletin entitled "Flowing Wells in Ontario" (Water Resources Bulletin 2-31) is available upon request from the Ministry of the Environment. This publication is an excellent reference on the locations of flowing wells in Ontario and should be consulted before having a well installed. Well contractors are usually aware of areas where flowing wells are likely to be encountered and should take special precautions when drilling in these areas.

TABLE 3. COMMON WATER QUALITY PROBLEMS

| PROBLEM | PROBABLE CAUSE | CORRECTIVE MEASURES |
|---|---|---|
| Mineral Scale build-up in kettles, water heaters and plumbing. Soap Scum, excess soap consumption, dingy laundry, bath-tub ring. | Hardness (hard water) | (1) Water softeners.<br>(2) Soluble Phosphate Additives. |
| Rusty to Black Stains on fixtures, laundry. Rusty to Black Water. Metallic Taste. | Iron and/or manganese | (1) Aeration and settling or Filtration.<br>(2) Greensand filters.<br>(3) Polyphosphate feeders.<br>(4) Water softeners.<br>(5) Chlorination-filtration units. |
| Gastro - Intestinal Disease including typhoid fever, dysentery, diarrhea. | Coliform bacteria, protozoa and viruses | (1) Eliminate source of contamination and disinfect.<br>(2) Boiling.<br>(3) Super-chlorination units (chlorination-filtration method).<br>(4) Ultra-violet systems.<br>(5) Chlorination-injector units. |
| Red to Brown Slime in toilet tanks and plumbing, reddish filament-like particles in water, Reduced Well Yield, sudden apearance of Iron Staining and Unpleasant Taste or Odors. | Iron bacteria | (1) Chlorination-filtration units.<br>(2) 'Shock chlorination' (Appendix F). |
| "Rotten-Egg" Smell and Taste, tarnish silver and copper, corrodes plumbing. | Hydrogen sulphide and/or sulphate reducing bacteria | (1) Chlorination-filtration units.<br>(2) Greensand filters.<br>(3) Aeration. |
| Salty Taste, corrosive. | Chloride | (1) Reverse-osmosis units. |
| Gassy Smell, gas bubbles escaping from water. | Gases (methane) | (1) Aeration.<br>(2) Activated carbon filters. |
| Cloudy Water. | Turbidity (clay) | (1) Filters.<br>(2) Alum treatment. |
| Water has Laxative Effects. | Sulphate | (1) Reverse-osmosis units. |
| Petroleum Smells or Film on water. | Gasoline and/or oil | (1) Activated carbon filters<br>(2) Gravity-separation system. |
| No Obvious Symptoms in adults but may cause a condition in infants called methemoglobinemia (child becomes listless and the skin takes on a blue colour). | Nitrate | (1) Reverse-osmosis units. |

## WATER QUALITY AND WATER QUALITY PROBLEMS

A water supply, in its natural state, should ideally be safe to drink, odorless and tasteless and should not stain laundry or plumbing fixtures. This is often not the case. Ground water, as it moves through the subsurface (Figure 2), picks up many impurities both through dissolving substances it encounters and carrying along contaminants such as bacteria, nitrates, spilled oil, etc. It is a common misconception that ground water because it is "filtered" by the soil is pure and therefore safe to drink. Many of the impurities in ground water can be removed by treatment processes to improve the water quality from a health, palatability and utilization standpoint.

This section contains standard procedures for collecting water samples, information on how to interpret the results and some of the common water-quality problems (Table 3) encountered in water supplies and the standard treatment methods to remedy these problems.

## WATER SAMPLING AND ANALYSES

It is a good practice upon the completion of a water well or when the water supply is suspect because of an unusual colour, taste or smell, to collect water samples and have them analysed for both chemical and microbiological constituents. The procedures for sampling and analysing chemical and microbiological constituents in the water supply vary somewhat and it is recommended that the following procedures be considered for use.

### Chemical analyses

Chemical analyses of water samples can be obtained from commercial laboratories and water-conditioning companies. These laboratories and companies are generally listed in the "yellow pages" phone directories.

Water samples should ideally be collected from a faucet outlet between the pump and any water treatment units and/or the water storage tank. Let the water run for at least five minutes before collecting the sample. For new wells, in addition to sampling done at the time of well completion, a sample should be collected about 30 to 60 days after the

well has been in use. This ensures that the sample is representative of the water in the aquifer.

The sample should be collected in a clean container, such as a new ½ to 1 litre size prescription bottle (sold in drug stores and obtained from water-quality laboratories) and should be at least 500 mL (about 17 fluid ounces) and preferably 1 litre (35 fluid ounces) in volume to provide the laboratory with sufficient sample for the analyses. The container should be rinsed several times with the water to be sampled and should be filled completely and capped tightly (to minimize oxidation effects). Take or ship the sample to the laboratory as quickly as possible so as to reduce the elapsed time between sampling and the analyses; thereby, reducing any chemical changes the water may undergo in the bottle.

You may wish to have the parameters listed in Appendix D analysed. This parameter list is by no means comprehensive as many other chemical constituents can be present. The listed parameters, do however, provide an indication of the chemical quality of the supply and its usability with reference to common health, and aesthetic considerations.

Microbiological analyses

Drinking water should be tested for the presence or absence of two groups of bacteria, total coliforms and fecal coliforms. These bacteria are considered to be "indicators" of the presence of animal wastes and sewage, in that they are present in large numbers in such wastes. Fecal coliforms are only found in intestinal contents of warm-blooded animals. They die fairly rapidly once outside the body and consequently their presence in water indicates relatively recent contamination. Water containing fecal coliform bacteria should not be consumed.

The Ontario Ministry of Health will provide bacterial analyses of water supplies free of charge. A list of Regional Public Health Laboratories is presented in Appendix E.

Sterile bottles are available from either the Health Laboratories or local Health Units. Detailed sampling and handling instructions are included with the bottles. These instructions should be followed closely so as not to contaminate the sample.

A water sample for microbiological analyses should be collected and analysed:

1. upon well completion and disinfection (before the well is used for drinking purposes),
2. one to three weeks later (after (1)) to confirm acceptable results,
3. following periods when the well has not been in use (in the case of seasonal residences), and
4. once or twice during the year, preferably after heavy rains.

The sample report will be returned to you indicating the results of the bacterial test.

## Interpretation of the chemical and microbiological analyses

The results of the chemical analyses of water samples are listed in numerical values representing the concentration of a particular constituent in the water sample. Most concentrations are given in milligrams per litre (mg/L) or parts per million (ppm). These two units, mg/L and ppm are commonly used interchangeably. One mg/L is one milligram of substance per litre of water, while one ppm is one part (by weight) of a substance in a million parts of solution.

Hardness is sometimes expressed in "grains per gallon" with one grain per gallon (gpg) equal to 17.1 mg/L (or 1 mg/L equal to 0.06 gpg).

The Province of Ontario has established a comprehensive list of recommended water quality objectives for public drinking water supplies. These objectives are designed as "guides" for water treatment purposes, to ensure that a public water supply meets specific health requirements and does not contain nuisance substances.

The water-quality objectives are either descriptive in nature or are assigned numerical values representing the concentration of a particular substance in water. Drinking water objectives are presented in Table 4; additional information is available in the publication "Water Management-Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment (1978)".

TABLE 4. RECOMMENDED WATER QUALITY OBJECTIVES FOR DRINKING WATER SUPPLIES (DRINKING WATER OBJECTIVES - APRIL, 1976)

| Substance | Concentration mg/L |
|---|---|
| Alkyl benzene sulfonate (ABS) | 0.5 |
| Arsenic (As) | 0.01 |
| Chloride (Cl) | 250.0 |
| Copper (Cu) | 1.0 |
| Carbon chloroform extract (CCE) | 0.2 |
| Cyanide (CN) | 0.01 |
| Fluoride (F) | (see Appendix D) |
| Iron (Fe) | 0.3 |
| Manganese (Mn) | 0.05 |
| Nitrate (N)** | 10.0 |
| Phenols | 0.001 |
| Sulphate ($SO_4$) | 250.0 |
| Total dissolved solids | 500.00 |
| Zinc (Zn) | 5.0 |
| Total Organic Carbon (C) | 5.0 |
| Organic Nitrogen (N) Total Kjeldahl minus free ammonia | 0.15 |
| Methane (Ground Waters only) | 50 cu.ft./100,000 gal. |

Rural ground-water supplies often exceed the recommended concentrations for one or more chemical parameters. Where this happens, if another water supply is available, it should be used. If such a supply is not available, the water may still be used, however, it is recommended that either the local Ministry of the Environment office (addresses listed in Appendix A) or the local Ministry of Health representative (addresses listed in Appendix E) be consulted for advice. It is generally possible to adopt some method of water treatment which will reduce the "exceeded parameter" thereby improving the water quality.

The microbiological (bacteriological) results are given in bacterial colony counts per 100 millilitres of sample. Presented below is a discussion of the significance of the bacteriological results (from the MOE publication titled Cottage Country, 1979).

Remember that strict numerical limits for safety are difficult to establish, and that as the number of coliform bacteria increases so does the risk of disease agents being present in the water.

| Coliform bacteria per 100 mL | | Interpretation |
|---|---|---|
| Total | Fecal | |
| >160 | >60 | Unsafe for drinking. This water is contaminated and should not be used for drinking under any circumstances. Do not attempt to apply these standards and interpretations to surface waters used for swimming. |
| 10-160 | 1-60 | Unsafe for drinking. Pollution source may be some distance from the water source, or diluted with large volumes of pure water, or the sample may not have been received within 48 hours of being taken. Samples older than 48 hours cannot provide reliable results. |
| 10- >160 | 0 | Unsafe for drinking. Contamination is not likely to be of sewage origin unless far removed from the water source or unless there has been a delay in receipt of sample. Common with new wells before disinfection and shallow dug wells which are not properly sealed. |
| 2-10 | 0 | Doubtful for a single sample, but safe for drinking if condition remains stable and supply is protected and located at least 100 ft. from any source of human or animal wastes. |
| >2 | 0 | Safe for drinking. Repeat samples may not show exactly the same results because bacteria are not distributed uniformly in water, contamination tends to enter intermittently and numbers can change during sample transit time. |
| Est | | Unsafe for drinking. Number has been estimated due to some interference with the test. Exact number is not really critical, especially if in excess of limits shown above, for judging safety. |
| O/G | | Doubtful condition and not recommended for drinking. No coliform bacteria could be detected because of "overgrowth" by other bacteria. This condition frequently occurs with new wells, dug wells receiving soil drainage, or wells which have been idle for sometime. Collect another sample and identify clearly "REPEAT SAMPLE". |

If coliform organisms are contained in the sample, in numbers which indicate the supply is unsafe, the water should be chlorinated or boiled before ingestion until further sampling indicates that the water is safe.

Chlorination of single batches of water (e.g. a gallon of water) is relatively simple. Using an eye dropper, add eight drops of household bleach (containing an average of 4% to 5 % available chlorine - concentration is usually indicated on the label) to each gallon of water. The water should then be stirred and left standing for at least 15 minutes before using. At the end of this time, the water should have a slight chlorine smell. If this is not the case, repeat the procedure. If the chlorine taste is too strong, the water can be left exposed to the air for a few hours before using.

The water should be brought to a rolling boil for at least 5 minutes to kill any bacteria. Various commercial water purifiers are discussed in a later section.

A discussion of a method for chlorinating the well and water distribution system is presented in Appendix F.

## HARDNESS

Hardness, or 'hard water' as it is frequently called, is a common characteristic of ground water in most areas of southern Ontario. Ground water as it moves through limestone bedrock or carbonate-rich overburden dissolves calcium and magnesium compounds which cause hardness. High hardness is a nuisance resulting in a scale formation on kettles, it prevents soap from lathering and it can cause a dingy appearance to the laundry. Two common water-treatment processes exist which can be used as corrective measures; these are water softeners and soluble phosphate additives.

### Water softeners

In a softening unit (Figure 18), hardness is removed from water by a process called ion exchange. Water flows over an ion exchange resin (synthetic zeolite) that is charged with sodium ions. The calcium and magnesium ions in the water are traded for sodium ions, thus making the water soft. When most of the available sodium ions in the exchange resin

have been replaced by calcium and magnesium, the unit must be regenerated with a brine (concentrated salt solution). Some of the newer water softeners are fully automatic and regenerate themselves on a predetermined time cycle. Softeners are available in many sizes. Sizing is determined by the amount of water used, the hardness of the water and the frequency of regeneration.

Water softeners increase the sodium content of the water. Those individuals on a low sodium diet or with high blood pressure (hypertension) or heat disease should consult their physician before drinking softened water on a daily basis.

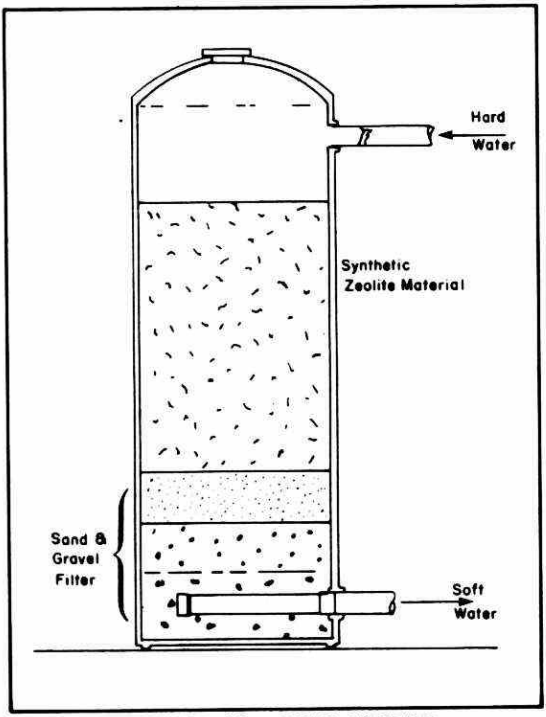


FIGURE 18. WATER SOFTENER.

Soluble phosphate additives

Phosphate additives are available for water softening. These softeners are added to hard water to prevent it from reacting with soap

or detergent to form a scum. These softeners keep the carbonates in their dissolved form and do not remove the carbonates in the water, thus a scale will still form in kettles etc.

## IRON AND MANGANESE

Ground water frequently contains iron and manganese in a colourless, dissolved form. Concentrations of iron in excess of 0.3 mg/L and manganese in excess of 0.05 mg/L are of concern for aesthetic reasons. When iron and manganese solutions come in contact with air (oxygen), the iron and manganese precipitate out. This results in the staining of plumbing fixtures and laundry, and discoloured or "rusty" water is produced because of the presence of flakes of these metals. Several methods are available which either remove or control these metals; some of these are discussed below.

### Aeration and settling or filtration

This method involves aerating the water in order to oxidize the iron and manganese, thus causing it to precipitate out of solution. The resulting precipitate is then either allowed to settle out in a tank or is filtered. This method is very effective; however, it should be followed by continuous chlorination to kill any airborne bacteria which may be introduced by aeration.

### Greensand filters

"Greensand" filters are an effective means for removing iron and manganese concentrations of up to 5 to 10 ppm. The "greensand" provides oxygen to the water passing through it. This oxidizes these metals resulting in their precipitating out and being filtered by the "greensand". These filters need to be backwashed and have their oxygen supply regenerated in order to ensure their effectiveness on a regular basis. This is achieved by flushing with a large volume of water and then rinsing the "greensand" with a solution of potassium permanganate.

The water system must be able to provide sufficient volumes of water to backwash the filters. If such a volume can not be provided it will be

necessary to use one of the other treatment methods. The presence of iron bacteria in the water can cause a slime buildup on the "greensand" reducing its effectiveness. It may be necessary to chlorinate the water before it enters the filter, to kill the bacteria.

Polyphosphate feeders

This method is effective in controlling iron and manganese concentrations of up to 2-5 ppm. A concentrated solution of polyphosphate is added to the water supply by a chemical feeder. The polyphosphate stabilizes the metals, thus preventing them from oxidizing and coming out of solution. There are two limitations to this method; first it will only prevent the metals' ions which have not as yet been oxidized from oxidizing and second, the polyphosphate may breakdown when the water is heated in a water heater, thus reducing the effectiveness of the polyphosphate.

Water softeners

Water softeners will remove amounts (up to 2 ppm) of iron and manganese from the water. It is necessary to maintain the metals in their dissolved forms (by keeping the oxidation to a minimum) otherwise the softener will rapidly become clogged. For this reason, it usually preferable to remove iron and manganese from the water before it enters the softener.

Chlorination-filtration units

Chlorine is a strong oxidizing agent and also acts as a disinfectant. The addition of a chlorine solution to the water will oxidize the iron and manganese, causing it to precipitate out. The water must then be run through a filter such as sand or activated charcoal to remove the metal precipitate. The activated charcoal will also remove any residual chlorine odors and tastes. These units are also effective in killing iron bacteria and coliform bacteria (chlorination) as well as eliminating hydrogen sulphide odor (activated charcoal).

## CHLORIDE, SULPHATE AND NITRATE

Ground waters with chloride and sulphate concentrations in excess of 250 ppm and nitrates in excess of 45 ppm (10 ppm of nitrogen) are not desirable for domestic water supplies. High chloride concentrations are readily identifiable by a salty taste in the water. Drinking water with high chloride concentrations is not harmful to health; however, high chloride concentrations are nearly always accompanied by high sodium concentrations. Those on a low sodium diet or with high blood pressure (hypertension), renal, or heart disease should consult their physicians before consuming such water on a daily basis.

High sulphate concentrations in water produce bad tastes and can have a laxative effect for individuals who are not accustomed to such waters.

High nitrate concentrations in water are often indicative of pollution. Nitrate is produced by bacterial action on human and barnyard waste and by fertilizers and the decomposition of plant matter. The presence of fecal coliform bacteria in the water, in addition to nitrate, indicates that the source of nitrates is likely septic tanks, or cesspools or barnyard wastes. High nitrate content may cause an oxygen-starved condition in infants known as methemoglobinemia. The child becomes listless and drowsy and the skin takes on a blue hue. Where high nitrates are present, the source of the problem should be identified and remedial measures taken wherever possible. Remedial measures may involve removing the source of the nitrates, providing better well protection or possibly having the well deepened or replaced.

The removal of chloride, sulphate and nitrate from the water supply is accomplished by a demineralization process known as reverse-osmosis.

### Reverse-osmosis units

In a reverse-osmosis unit, mineralized water is forced through a semi-permeable membrane. The membrane passes fresh water; the minerals are left behind. These units are generally expensive and will only treat a few gallons of water per day, enough for drinking and cooking. If a larger supply of water is needed, it may be necessary to either find a new water source or else add additional treatment units to the system.

## BACTERIA, PROTOZOA AND VIRUSES

Only a few of the many different kinds of bacteria, protozoa and viruses are pathogenic (disease-causing). Ground water for the most part does not contain any of these harmful organisms unless it has become polluted by surface water or seepage from sewage facilities.

Water-well contractors are required by law to seal the upper portion of wells so that surface water or seepage from septic tanks, privies or cesspools cannot enter the well. Many wells, particularly those that are dug or bored, become polluted because the upper portion of the well is not carefully sealed.

The procedure for verifying whether your well water is safe to drink is discussed under the sections "Microbiological Analyses" and "Interpretation of Chemical and Microbiological Analyses".

If the source of the contamination appears to be septic tank effluent or barnyard wastes, an alternative source of water supply should be found or a commercial water purifier should be installed. The user is cautioned that such waters may also contain high nitrate concentrations. This should be verified especially where there are young children in the household. Three types of purifiers are available for domestic use: super-chlorination units, ultra-violet irradiation units and chlorination-injector systems.

Following the installation of a water purifier, the water should be retested to ensure thjat the purifier is working properly.

### Super-chlorination units

The super-chlorination unit is installed in the distribution system either before or immediately after the pump. As the water-pump is activated, the unit drains a strong solution of chlorine from a container and feeds it into the water. The strong solution reduces the contact time required to kill organisms but leaves a high chlorine residue in the water that gives it an objectionable taste and odor. The water can be de-chlorinated by passing it through an activated carbon filter.

### Ultra-violet systems

In the ultra-violet irradiation unit, water passes over an ultra-violet tube. Ultra-violet rays emitted by the tube will kill bacteria in the water. There is a danger that the period of time the water is under the ultra-violet light (contact time) may not be long enough to kill all of the bacteria. In addition the effectiveness of the ultra-violet rays in killing bacteria is reduced if the water is turbid or coloured. Both of these concerns can be corrected by adjustments to the system.

### Chlorination-injector units

This unit feeds a weak solution of chlorine into the water-distribution system immediately after it comes from the well. The water must then be pumped into a pressure or storage tank which is large enough to ensure that the water will be stored long enough (approximately 20 minutes) to provide adequate contact time for the chlorine to kill any bacteria.

## IRON BACTERIA

Iron bacteria occur in ground water. They are non-injurious to health but are nuisance organisms that can cause plugging of the pores in water-bearing formations and openings in well screens. Iron bacteria can be transported from one location to another on drilling tools. Contractors are required to disinfect all new wells they construct and they should chlorinate any waters they use for drilling purposes.

The bacteria produce accumulations of slimy material and deposit iron. The combined effect of the growth of organisms and the deposition of materials can completely plug a well in a relatively short time.

Chlorine is an effective means of controlling iron bacteria. The chlorine kills the bacteria destroying the slime deposits on the well screens and in the surrounding aquifer. (see Appendix F for instructions on chlorinating a well). Unfortunately, iron bacteria are difficult to eradicate permanently and treatment of the well may have to be repeated periodically. To rid a well of iron bacteria, you may have to hire a water-well contractor who is experienced in handling strong solutions of

chlorine. Chlorination-filtration units are effective in controlling iron bacteria in the distribution system.

## HYDROGEN SULPHIDE AND SULPHATE REDUCING BACTERIA

Hydrogen sulphide is a gas that can be recognized by its disagreeable "rotten egg" odor. Water containing hydrogen sulphide is also corrosive and will attack the plumbing system.

Some ground water which contains natural concentrations of sulphate may also contain sulphate-reducing bacteria. These bacteria change the sulphate to hydrogen sulphide and weak sulphuric acid. The formation of hydrogen sulphide and sulphuric acid makes the water more corrosive and speeds up the attack on metals.

Sulphate-reducing bacteria do not require oxygen to live (anaerobic). Since hot water contains less oxygen than cold water, the bacteria can live in hot water tanks. Their presence is suspected if hydrogen sulphide (rotten egg) odor comes from just the hot water taps.

Chlorination-filtration is a satisfactory way of removing hydrogen sulphide from water. (see Iron Section). The chlorine oxidizes the hydrogen sulphide and forms a precipitate of sulphur; it also removes any sulphur bacteria present in the water. The sulphur precipitate is removed by a sediment filter and excess chlorine in drinking water is removed by an activated carbon filter.

These bacteria and hydrogen sulphide may also be removed by super-chlorination followed by filtration with a carbon filter. Bubbling air through the water and splash aeration (running water over baffles while it is exposed to the air) also help to get rid of the hydrogen sulphide (rotten egg) odor.

Table 5 from the Water Well Journal (July, 1979) presents advantages and disadvantages of various methods.

TABLE 5. CONVENTIONAL HYDROGEN SULPHIDE TREATMENT METHODS
(WATER WELL JOURNAL - JULY, 1979)

| Method | Advantages | Disadvantages |
|---|---|---|
| Oxidizing filters (potasium permanganate) "greensand" filters | Can remove up to 6 mg/L of sulphide | Sulphur clogs used filter |
| Chlorination | Quick and effective | Extra equipment needed. Potentially corrosive water produced. Chlorine residual taste. |
| Ozonation | Quick and effective | High initial cost |
| Aeration | No chemicals required | Prolonged contact times. Second tank required for repressuring water. Space required for aeration units. Must be protected from freezing. |
| Activated carbon filtration | Removes mild taste and odor problems caused by $H_2S$ | Useful only in concentrations less than 1 mg/L |

GASOLINE AND OIL

Well contamination from the leakage or spillage of petroleum products is an extremely difficult and expensive problem to rectify. This is because, petroleum products are by nature:

1) relatively stable and will not readily decompose in the subsurface,

2) are capable of travelling long distances with ground water, both as a liquid and in solution,
3) will adhere to soil particles and be released only slowly by the flushing action of infiltrating precipitation, and
4) will release explosive vapors which are of concern when handling contaminated materials.

In addition, even small quantities of petroleum in the water will render it unfit for consumption due to taste and odor. Therefore, the best solution to this problem is one of prevention.

Where a leak or spill does occur or else a petroleum-like taste or odor is detected in the water supply, it should be reported immediately to the local Ministry of the Environment Regional Office. Depending on the local hydrogeology and hydrocarbon concentrations, clean-up procedures can be very elaborate such as that involving the excavation and removal of contaminated materials to an approved landfill site, or may involve simply adding an activated carbon filter to the water distribution system.

## GAS (METHANE)

Many water wells, particularly in southwestern Ontario, produce water containing some natural gas. Natural gas escaping into an enclosed well pit or shed has been known to cause explosions and fires. A well containing natural gas should be sealed at the top and fitted with an air vent that lets the gas into the atmosphere at least 8 feet above ground level.

Sometimes, if a strong flow of natural gas is encountered, it is necessary for drilling Contractors to leave the well site for a short period (usually 10 days is sufficient) during which time the gas is allowed to flow to the atmosphere unrestricted. During the period, signs warning of the presence of explosive gas should be posted at the site.

Natural gas may also cause water pumps to lose their prime. A gas separator diverting gas away from the pump intake will protect the pump and improve its operation (Figure 19). The use of aeration and activated carbon filters should also remove any gas which may enter the distribution system. Considerable care should be taken because of the explosion hazard present whenever work is done on a well that produces gas with the water supply.

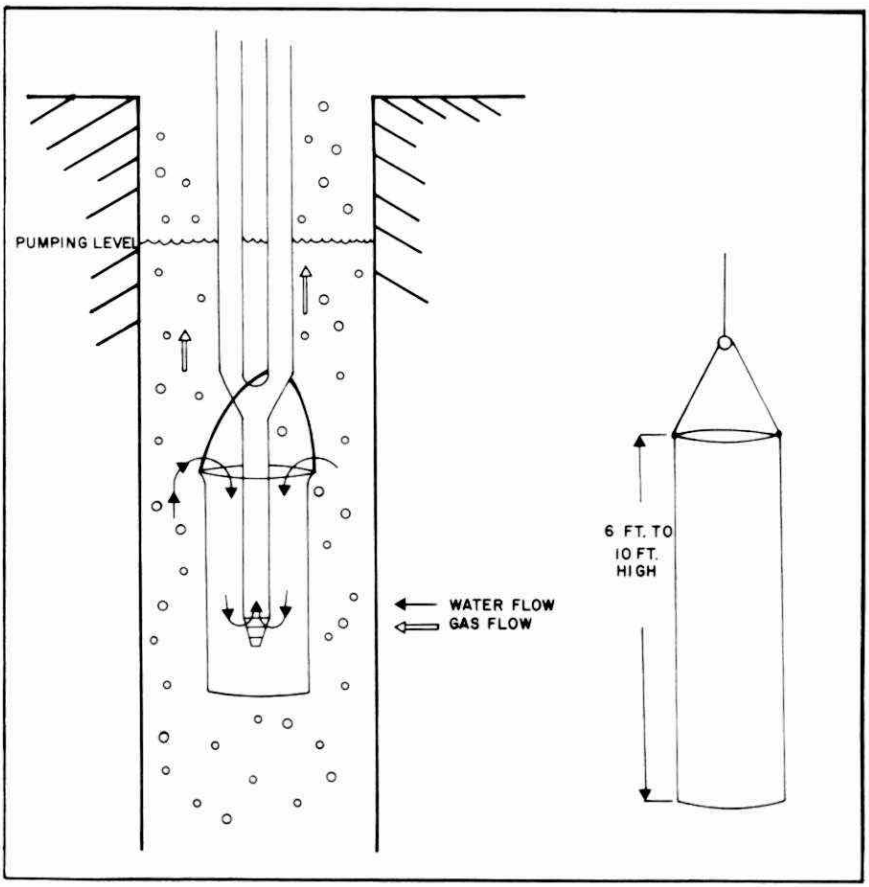


FIGURE 19. GAS SEPARATOR.

## TURBIDITY

In some new wells the water is turbid or cloudy. This results from a fine suspension of clay, silt, organic matter or other contaminants which remain in the water. A common method of treating a new well supply is to add a few teaspoons of alum (a double sulphate of aluminum and potassium) to the water to coagulate the fine particles. The particles should settle to the bottom of the well and the water should become clear. As the well is developed by pumping, the problem should disappear. Where turbidity remains, it may be necessary to add a filter to remove fine particles.

### Filters

Sand and diatomite filters are commonly used to remove fine-grained particles in water. A diatomite filter consists of a filter cake of diatomaceous earth. Water is forced through the filter removing all turbidity. The filter should be back washed regularly to maintain its effectiveness. Other filters which are used, include carbon, cloth, porous stone and paper. These filters come in cartridges which can be added to the water lines. The cartridge is replaced periodically. Most water conditioning companies carry a variety of filters and are a good source of information on turbidity related problems.

## MAINTENANCE, RECONSTRUCTION AND REPAIRS OF EXISTING WELLS

A new well, pump and distribution system are expensive; therefore, care should be taken to maintain existing systems in a sanitary and serviced condition. In addition, access to the well should remain unobstructed.

At regular intervals, an inspection of the well and surroundings should be undertaken to ensure that:

1. The well seal or casing cap is securely in place.
2. No openings have developed around or through the casing, due to subsidence, corrosion, or damage through which surface water and debris can enter.
3. Surface-water drainage in the vicinity of the well is directed away from the well.
4. The air vent is unobstructed.
5. No refuse, manure, petroleum, salt, or other potential contaminants are stored or disposed of in the vicinity of the well.

The pump and distribution system should be serviced as specified in the manufacturers' service manuals. Exposed wiring, frayed contacts, damp or wet condition and other potentially hazardous situations should be corrected as noticed.

Dug wells, where they do not conform to the Province's well standards, should be reconstructed or repaired. This can be done by having the upper eight feet of the well set with watertight joints and the top sealed in such a manner that surface water or other material cannot enter.

Conditions such as reduced well yield, sand in the water, and certain common water quality and water distribution problems are discussed elsewhere in the text.

## WELL ABANDONMENT

Improperly abandoned wells are a hazard to public health and physical safety. Accidents have occurred where children have fallen into large diameter abandoned wells. Abandoned wells should be carefully sealed to prevent pollution of the ground water, to conserve aquifer yield and artesian pressure (particularly in the case of flowing wells) and to prevent poor quality ground water from moving between water bearing zones.

A brochure entitled "Recommended Methods for Plugging Abandoned Water Wells" is available upon request from the Ministry of the Environment. It is recommended that anyone planning to abandon a well obtain this brochure before doing so. Employment of a well contractor familiar with abandonment procedures is usually advisable, especially in cases involving deep or flowing wells or wells in fractured bedrock.

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# APPENDIX A

A listing of individual publications released by the Water Resources Branch of the Ministry of the Environment along with maps showing the locations of the Ministry's Regional Offices and the areal coverage of these publications.

| MICROFICHE NO. | | WATER RESOURCES REPORTS |
|---|---|---|
| 256-79 | 1 | Water Resources of the Big Otter Creek Drainage Basin(s), by U. Sibul, 91 pp. (1969). |
| 257-79 | 2 | Water Resources of the Big Creek Drainage Basin, by T. J. Yakutchik and W. Lammers, 172 pp. (1970). |
| 258-79 | *3 | Water Resources of the Upper Nottawasaga River Drainage Basin, by U. Sibul, K. Goff and A. V. Choo-Ying, 128 pp. (1971). |
| 242-79 | 4 | Evaluation of the Ground Water Storage Capacity in the Soper Creek Sub-basin Using the Physical Parametric Approach by M. Barouch, 45 pp. (1971). |
| 259-79 | 5b | The Hydrogeology of the IFYGL Forty Mile and Oakville Creeks Study Areas, by R. C. Ostry, 44 pp. (1979). |
| | 5c | The Hydrogeology of the IFYGL Duffins Creek Study Area, by R. C. Ostry, 39 pp., 1979. |
| 75-0422 | 5d | A Hydrogeological Study along the North Shore of Lake Ontario in the Bowmanville-Newcastle Area, by S. N. Singer, 72 pp. (1974). |
| | 5e | The Hydrogeology of the IFYGL Moira River, Wilton Creek and The Thousand Islands Study Areas, by R. C. Ostry, 40 pp., (to be released in 1980). |
| 260-79 | 6 | Water Resources of the Moira River Drainage Basin, by U. Sibul, K. Goff and A. V. Choo-Ying, 115 pp. (1974). |
| 261-79 | *7 | Geology and Ground Water Resources of the Wilton Creek IHD Representative Drainage Basin, by Gunther Funk, 96 pp. (1977). |

*Out of print

continued

| MICROFICHE NO. | | WATER RESOURCES REPORTS |
|---|---|---|
| 262-79 | 8 | Ground Water Resources of the Duffins Creek-Rouge River Drainage Basins, by U. Sibul, K. T. Wang and D. J. Vallery, 109 pp. (1978). |
| 263-79 | 9a | Geology and Water Resources of the Bowmanville, Soper and Wilmot Creeks IHD Representative Drainage Basin, by Gunther Funk, 113 pp. (1977). |
| 264-79 | 10 | Hydrogeology and Ground Water Model of the Blue Springs Creek I.H.D. Representative Drainage Basin, by J. M. H. Coward and M. Barouch, 108 pp. (1978). |
| 265-79 | 11a | Northern Ontario Water Resources Studies, General Characteristics and Frequency Analyses of Streamflows, by V. I. Chin and J. D. Eddie (1978). |
| 266-79 | 11b | Northern Ontario Water Resources Studies, Ground-Water Resources, by K. T. Wang and V. I. Chin, 121 pp.(1978). |
| 267-79 | 11c | Northern Ontario Water Resources Studies, The Water Quality of Selected Lakes in the Arctic Watershed of Ontario, by A. C. Roy, 95 pp. (1979). |
| | 12 | Geology and Water Resources of the East and Middle Oakville Creeks IHD Representative Drainage Basin, by Gunther Funk, 68 pp. (1979). |
| | 13 | Water Resources of the South Nation River Basin by V. I. Chin, K. T. Wang and D. J. Vallery, (to be released in 1980). |
| | 14 | Water Resources of the Holland and Black River Basins by D. J. Vallery, K. T. Wang and V. I. Chin, (in progress). |

| MICROFICHE NO. | | WATER RESOURCES BULLETINS |
|---|---|---|
| 213-79 | *1 | Ground Water in Ontario 1953 and 1954, 1961, 302 pp. |
| 214-79 | *2 | Ground Water in Ontario 1955 and 1956, 1963, 377 pp. |
| 215-79 | *3 | Ground Water in Ontario 1957, 1965, 205 pp. |
| 216-79 | *4 | Ground Water in Ontario 1958, 1966, 377 pp. |
| 217-79 | *5 | Ground Water in Ontario 1959, 1966, 320 pp. |
| 218-79 | *6 | Ground Water in Ontario, Southwestern Area 1960-1963, 1968, 485 pp. |
| 219-79 | *2-7 | Ground Water in Ontario, South Central Area 1960-64, 1969, 605 pp. |
| 220-79 | *2-8 | Ground Water in Ontario, Southeastern Area 1960-64, 1970, 307 pp. |
| 221-79 | 2-9 | Water Well Records for Ontario, Northern Area 1946-69, 1972, 617 pp. |
| 222-79 | *2-10 | Ground Water in Ontario, Southwestern Area 1964-67, 1970, 538 pp. |
| 223-79 | *2-11 | Ground Water in Ontario, South Central Area, 1965-67, 1971, 408 pp. |
| 200-79 | *2-12 | Water Well Records for Ontario - Durham, Northumberland, Victoria, 1946-69, 1975, 452 pp. |
| 74-0190 | *2-13 | Water Well Records for Ontario - Haliburton, Peterborough, 1946-69, 1974, 278 pp. |
| 201-79 | *2-14 | Water Well Records for Ontario - Hastings, Lennox and Addington, Prince Edward, 1946-1972, 1976, 491 pp. |
| 202-79 | *2-15 | Water Well Records for Ontario - Frontenac, Lanark, Renfrew, 1946-69, 1974, 403 pp. |
| 203-79 | 2-16 | Water Well Records for Ontario - Regional Municipality of Ottawa-Carleton, 1946-1972, 1976, 553 pp. |
| 204-79 | 2-17 | Water Well Records for Ontario - Leeds and Grenville, 1946-1972, 1976, 311 pp. |
| 205-79 | 2-18 | Water Well Records for Ontario - Dundas, Glengarry, Prescott, Russell, Stormont, 1946-1972, 1977, 263 pp. |
| 206-79 | *2-19 | Water Well Records for Ontario - Essex, 1946-1974, 1977, 223 pp. |

* Out of print

Continued ....

| MICROFICHE NO. | | WATER RESOURCES BULLETINS |
|---|---|---|
| 207-79 | 2-20 | Water Well Records for Ontario - Kent and Lambton, 1946-1974, 1977, 608 pp. |
| 208-79 | 2-21 | Water Well Records for Ontario, Regional Municipalities of Halton and Peel, 1978, 501 pp. |
| 209-79 | 2-22 | Water Well Records for Ontario - Elgin, Middlesex 1946-1975, 1978, 609 pp. |
| 210-79 | 2-23 | Water Well Records for Ontario - Regional Municipality of Haldimand-Norfolk 1946-1975, 1978, 273 pp. |
| 486-79 | 2-24 | Water Well Records for Ontario - Huron, Oxford, Perth, 1946 - 1976, 1979, 641 pp. |
| | 2-25 | Water Well Records for Ontario - Bruce, Dufferin and Grey, 1946-1977, 1980. |
| | 2-26 | Water Well Records for Ontario - Wellington - Waterloo, 1946-1977 (to be released in 1980). |
| | 2-27 | Water Well Records for Ontario - Simcoe, 1946-1977 (to be released in 1980). |
| | 2-28 | Water Well Records for Ontario - Niagara, 1946-1978 (to be released in 1980). |
| | 2-29 | Water Well Records for Ontario - Hamilton - Wentworth, Brant, 1946-1978 (to be released in 1981). |
| | 2-30 | Water Well Records for Ontario - York, 1946-1978 (to be released in 1981). |
| | 2-31 | Flowing Wells in Ontario |
| 211-79 | 2-101 | Data for Observation Wells in Ontario 1974 |
| 212-79 | 2-102 | Data for Observation Wells in Ontario 1975 |
| 160-79 | 2-103 | Data for Observation Wells in Ontario 1976 |
| 336-79 | 2-104 | Data for Observation Wells in Ontario 1977 |
| 550-80 | 2-105 | Data for Observation Wells in Ontario 1978 |

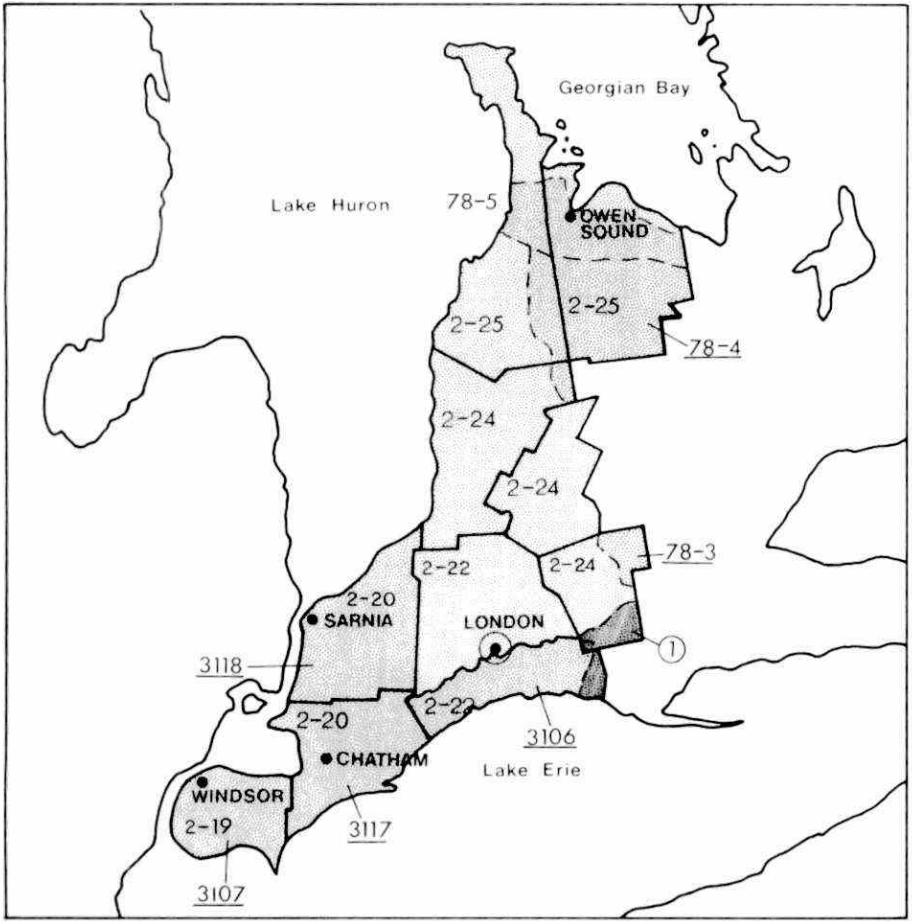
| WATER RESOURCES MAP NO. | WATER RESOURCES MAP |
|---|---|
| *3100 | Ground Water Probability, County of Brant, 1977 |
| 3106-1-4 | Ground Water Probability, County of Elgin, 1972 |
| *3107-1 | Ground Water Probability, County of Essex, 1971 |
| *3112 | Ground Water Probability, County of Haldimand, 1974 |
| *3117 | Ground Water Probability, County of Kent, 1969 |
| *3118-1 | Ground Water Probability, County of Lambton, 1970 |
| 3124 | Ground Water Probability, Region of Haldimand-Norfolk (Western Portion), 1979 |
| 3128 | Ground Water Probability, Regional Municipality of Peel, (1979). |
| *77-1 | Alliston Aquifer Complex, 1977 |
| *78-2 | Oak Ridges Aquifer Complex, 1977 |
| 78-3 | Guelph-Amabel Aquifer, Hamilton to Orangeville, 1978 |
| 78-4 | Guelph-Amabel Aquifer, Orangeville to Markdale, 1978 |
| 78-5 | Guelph-Amabel Aquifer, Markdale to Owen Sound, 1978 |
| 78-6 | Guelph-Lockport Aquifer, 1978 |

*Out of print

# Southwestern Region

(1)

Ministry of the Environment
Ontario




REGIONAL OFFICE

LONDON
985 Adelaide St.S.
519-681-3600

DISTRICT OFFICES

WINDSOR
250 Windsor Ave.
519-254-5129

SARNIA
242 A Indian Rd.S.
519-336-4030

OWEN SOUND
220 11th St.E.
519-371-2901

SUB-OFFICE

CHATHAM
435 Grand Ave.W.
519-352-5107

WATER RESOURCES BULLETINS

2-19, 2-20, 2-22, 2-24, 2-25.

WATER RESOURCES REPORTS

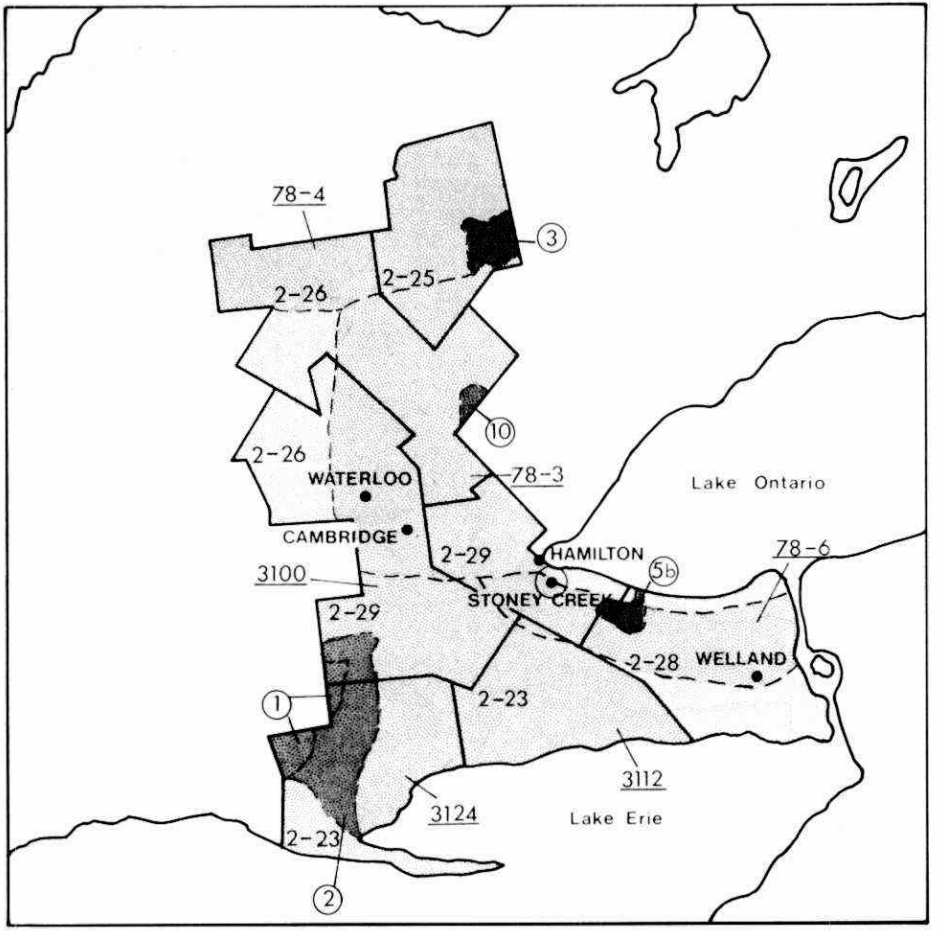
(1)

WATER RESOURCES MAPS

3107, 3106, 3117, 3118, 78-3, 78-4, 78-5.

# West Central Region

Ministry of the Environment
Ontario




REGIONAL OFFICE

STONEY CREEK
140 Centennial Pkwy. N.
416-561-7410

DISTRICT OFFICES

WELLAND
637-641 Niagara St. N.
416-735-0431

CAMBRIDGE
400 Clyde Road
P.O. Box 219
519-623-2080

SUB-OFFICE

SIMCOE
645 Norfolk St. N.
519-426-1940

WATER RESOURCES BULLETINS

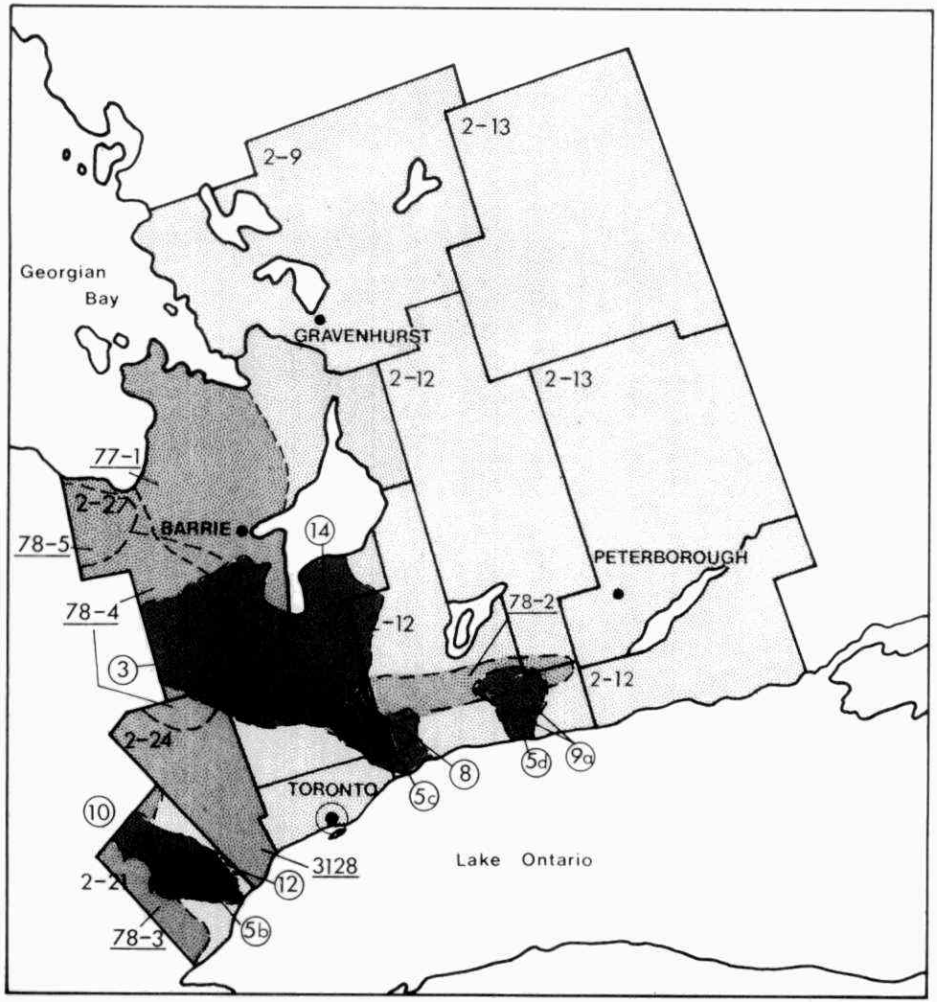
2-23, 2-25, 2-26, 2-28, 2-29.

WATER RESOURCES REPORTS

(1), (2), (3), (5b), (10).

WATER RESOURCES MAPS

3100, 3112, 3124, 78-4, 78-3, 78-6.




# Central Region

(3)

Ministry of the Environment
Ontario

REGIONAL OFFICE

DON MILLS
150 Ferrand Dr.
416-424-3000

DISTRICT OFFICES

BARRIE
12 Fairview Rd.
705-726-1730

PETERBOROUGH
139 George St. N.
705-743-2972

MUSKOKA-HALIBURTON
Gravenhurst Shopping Centre
705-687-3408

HALTON-PEEL
1226 White Oaks Blvd.
Oakville
416-844-5747

SUB-OFFICE

HUNTSVILLE
100 Main St. E.
705-789-2386

WATER RESOURCES BULLETINS

2-9, 2-12, 2-13, 2-21, 2-24, 2-27, 2-30.

WATER RESOURCES REPORTS

(3), (5b), (5c), (5d), (8), (9a), (10), (12), (14).

WATER RESOURCES MAPS

3128, 77-1, 78-2, 78-3, 78-4, 78-5.

# Southeastern Region

Ministry of the Environment
Ontario

REGIONAL OFFICE

KINGSTON
133 Dalton St.
613-549-4000

DISTRICT OFFICES

BELLEVILLE
15 Victoria Ave.
613-962-9208

OTTAWA
2378 Holly Lane
613-521-3450

CORNWALL
4 Montreal Rd.
613-933-7402

PEMBROKE
1000 MacKay St.
P.O. Box 67
613-732-3643

WATER RESOURCES BULLETINS

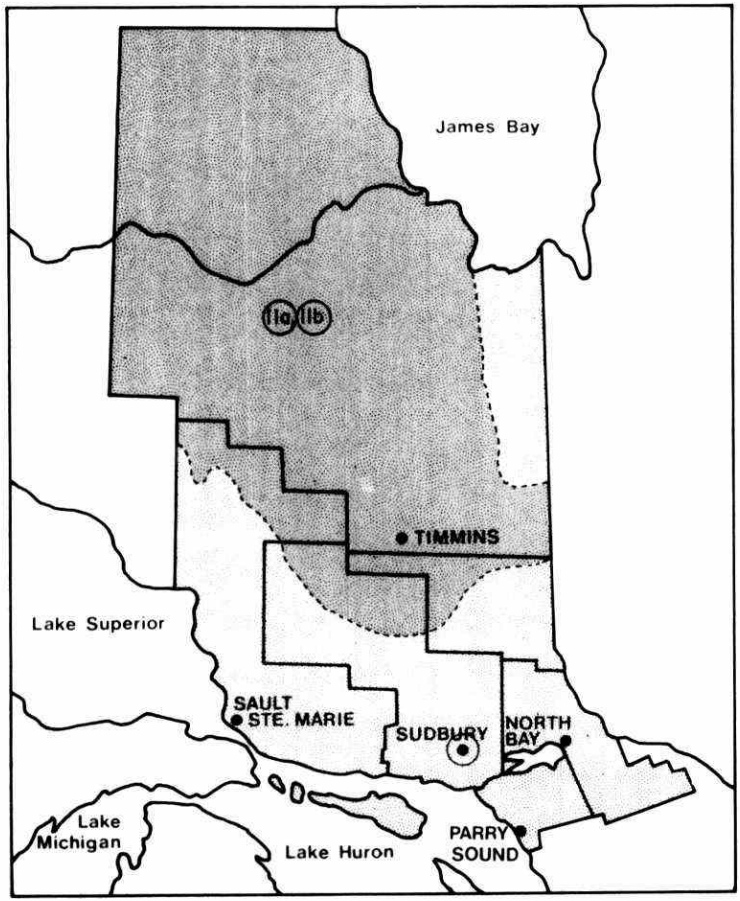
2-9, 2-14, 2-15, 2-16, 2-17, 2-18.

WATER RESOURCES REPORTS

(5e), (6), (7), (13).

# Northeastern Region
(5)

Ministry of the Environment
Ontario




REGIONAL OFFICE

SUDBURY
469 Bouchard St.
705-522-8282

DISTRICT OFFICES

NORTH BAY
1500 Fisher St.
705-476-1001

SAULT STE. MARIE
445 Albert St. E.
705-949-4640

TIMMINS
83 Algonquin Blvd. W.
705-264-9474

PARRY SOUND
74 Church St.
705-746-2139

WATER RESOURCES BULLETIN
2-9

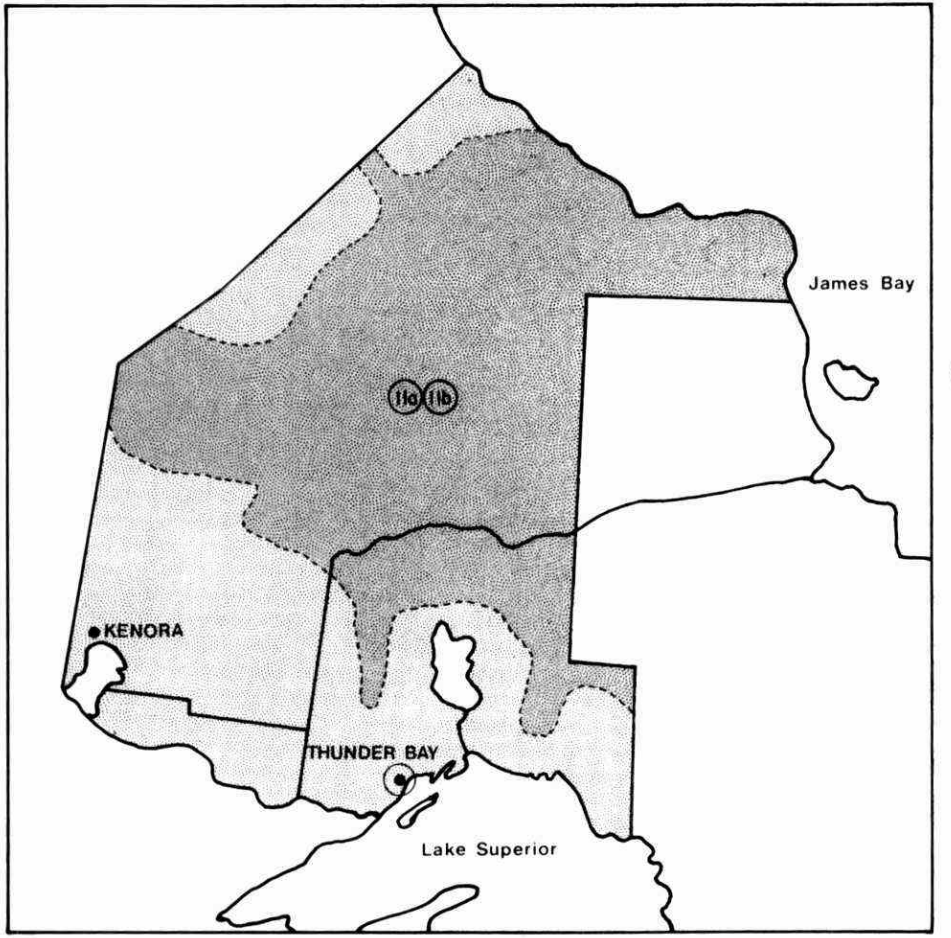
WATER RESOURCES REPORTS
(11a), (11b).

# Northwestern Region

6

Ministry of the Environment

Ontario




REGIONAL OFFICE

THUNDER BAY
435 James St.S.
P.O. Box 5000
807-475-1205

DISTRICT OFFICE

KENORA
808 Robertson St.
807-468-5578

WATER RESOURCES BULLETIN

2-9

WATER RESOURCES REPORTS

11a, 11b.

# APPENDIX B

## WATER WELL RECORD FORM

Ministry of the Environment
Ontario

The Ontario Water Resources Act

# WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

| COUNTY OR DISTRICT | TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE | CON. BLOCK, TRACT, SURVEY, ETC. | LOT |
|---|---|---|---|
| | | | |

| OWNER (SURNAME FIRST) | ADDRESS | DATE COMPLETED |
|---|---|---|
| | | DAY ____ MO ____ YR ____ |

## LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

| GENERAL COLOUR | MOST COMMON MATERIAL | OTHER MATERIALS | GENERAL DESCRIPTION | DEPTH - FEET FROM | DEPTH - FEET TO |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| | | | | | |

## WATER RECORD

| WATER FOUND AT - FEET | KIND OF WATER | | |
|---|---|---|---|
| | ☐ FRESH | ☐ SULPHUR | |
| | ☐ SALTY | ☐ MINERAL | |
| | ☐ FRESH | ☐ SULPHUR | |
| | ☐ SALTY | ☐ MINERAL | |
| | ☐ FRESH | ☐ SULPHUR | |
| | ☐ SALTY | ☐ MINERAL | |
| | ☐ FRESH | ☐ SULPHUR | |
| | ☐ SALTY | ☐ MINERAL | |
| | ☐ FRESH | ☐ SULPHUR | |
| | ☐ SALTY | ☐ MINERAL | |

## CASING & OPEN HOLE RECORD

| INSIDE DIAM. (INCHES) | MATERIAL | WALL THICKNESS (INCHES) | DEPTH - FEET FROM | DEPTH - FEET TO |
|---|---|---|---|---|
| | ☐ STEEL | | | |
| | ☐ GALVANIZED | | | |
| | ☐ CONCRETE | | | |
| | ☐ OPEN HOLE | | | |
| | ☐ STEEL | | | |
| | ☐ GALVANIZED | | | |
| | ☐ CONCRETE | | | |
| | ☐ OPEN HOLE | | | |
| | ☐ STEEL | | | |
| | ☐ GALVANIZED | | | |
| | ☐ CONCRETE | | | |
| | ☐ OPEN HOLE | | | |

## SCREEN

| SIZE (S. OF OPENING (SLOT NO.)) | DIAMETER INCHES | LENGTH FEET |
|---|---|---|
| | | |

| MATERIAL AND TYPE | DEPTH TO TOP OF SCREEN FEET |
|---|---|
| | |

## PLUGGING & SEALING RECORD

| DEPTH SET AT - FEET FROM | TO | MATERIAL AND TYPE (CEMENT GROUT, LEAD, PACKER, ETC.) |
|---|---|---|
| | | |
| | | |
| | | |

## PUMPING TEST

| PUMPING TEST METHOD | PUMPING RATE | DURATION OF PUMPING |
|---|---|---|
| ☐ PUMP ☐ BAILER | GPM | HOURS MINS |

| STATIC LEVEL | WATER LEVEL END OF PUMPING | WATER LEVELS DURING | | | |
|---|---|---|---|---|---|
| | | ☐ PUMPING ☐ RECOVERY | | | |
| | | 15 MINUTES | 30 MINUTES | 45 MINUTES | 60 MINUTES |
| FEET | FEET | FEET | FEET | FEET | FEET |

| IF FLOWING GIVE RATE | PUMP INTAKE SET AT | WATER AT END OF TEST |
|---|---|---|
| GPM | FEET | ☐ CLEAR ☐ CLOUDY |

| RECOMMENDED PUMP TYPE | RECOMMENDED PUMP SETTING | RECOMMENDED PUMPING RATE |
|---|---|---|
| ☐ SHALLOW ☐ DEEP | FEET | GPM |

## LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.

DRILLERS REMARKS

## FINAL STATUS OF WELL

☐ WATER SUPPLY
☐ OBSERVATION WELL
☐ TEST HOLE
☐ RECHARGE WELL
☐ ABANDONED, INSUFFICIENT SUPPLY
☐ ABANDONED, POOR QUALITY
☐ UNFINISHED

## WATER USE

☐ DOMESTIC
☐ STOCK
☐ IRRIGATION
☐ INDUSTRIAL
☐ COMMERCIAL
☐ MUNICIPAL
☐ PUBLIC SUPPLY
☐ COOLING OR AIR CONDITIONING
☐ OTHER _____
☐ NOT USED

## METHOD OF DRILLING

☐ CABLE TOOL
☐ ROTARY (CONVENTIONAL)
☐ ROTARY (REVERSE)
☐ ROTARY (AIR)
☐ AIR PERCUSSION
☐ BORING
☐ DIAMOND
☐ JETTING
☐ DRIVING

## CONTRACTOR

| NAME OF WELL CONTRACTOR | LICENCE NUMBER |
|---|---|
| | |

| ADDRESS | |
|---|---|
| | |

| NAME OF DRILLER OR BORER | LICENCE NUMBER |
|---|---|
| | |

| SIGNATURE OF CONTRACTOR | SUBMISSION DATE |
|---|---|
| | DAY ____ MO ____ YR ____ |

## OFFICE USE ONLY

**CONTRACTOR'S COPY**

FORM NO. 0506—4—77 FORM 7

# APPENDIX C

## CONSIDERATIONS WHEN DRAWING UP A CONTRACT

Appendix C

Listed below are example phrases for consideration when drawing up a contract with your water-well contractor

1. The Owner hereby retains the services of the Contractor to construct on the lands of the Owner a well _____ inches in diameter for the purposes of constructing a water well.

2. The Contractor agrees to construct the well having a diameter as indicated in Clause 1, to supply and install the proper and necessary casing and to install and develop to an essentially sand free state a well screen if required, for the prices referred to in Clause 4.

3. The Contractor agrees to endeavor to construct the said well to a sufficient depth to obtain the proper quality and quantity of water and to properly install no less than 10 lineal feet of casing therein.

4. The Owner agrees to pay to the Contractor for the work referred to in this Agreement, $_____ per lineal foot of well construction $_____ per lineal foot of casing and $_____ per lineal foot of sand screen, which shall be paid as follows:

(a) $_____ on signing of this Agreement by the Contractor, and

(b) the balance in a lump sum upon the work being completed to the satisfaction of the Owner.

5. At a depth of _____ feet, providing sufficient water has not been encountered above this said depth, permission from the owner to construct beyond the said depth shall be obtained and the contractor shall construct to a further depth to be agreed upon by the parties hereto (at a price and on terms to be agreed upon by the parties hereto).

6. It is hereby agreed that the lineal foot for construction shall be determined by measuring from the surface of the land to the bottom of the constructed well in the presence of the owner or his representative and that the lineal footage of casing and well screen shall be determined in accordance with the amount actually installed by the Contractor.

7. The Contractor shall ensure that the said water well is constructed, cased, tested and completed in compliance with Ontario Regulation 648/70.

8. The Contractor warrants and guarantees that the work to be performed by it or him under this Agreement shall be executed and completed in a proper and workmanlike manner but does not warrant or guarantee that water will be obtained or that water, if obtained, will be of a sufficient or proper quality or quantity.

9. Upon completion of the work to be performed by the Contractor under this Agreement, the Contractor shall complete a Water Well Record form prescribed by the Ministry of the Environment for the Province of Ontario and shall forward a copy of such Report to the Water Resources Branch, Ministry of the Environment, and a copy to the Owner.

10. The Owner shall permit the Contractor, its officers, servants, employees and agents, free and unobstructed access to the site of the said water well for the purpose of carrying out the provisions of this Agreement.

# APPENDIX D

## SUGGESTED LIST OF CHEMICAL PARAMETERS

Appendix D

## SUGGESTED LIST OF CHEMICAL PARAMETERS

### Health Considerations

Nitrate - nitrate is a pollutant usually associated with septic systems and agricultural practices. When nitrate is present in the supply in concentrations greater than 10 mg/L (as N), the supply should not be used for infant feeding where other more suitable supplies are or can be made available; see discussion of nitrate in text.

Sodium - There are no limits in the "Drinking Water Objectives". High sodium concentrations can have an adverse affect on people with cardiac, renal and circulatory problems. Appropriate health authorities should be consulted when sodium concentrations are greater than 20 mg/L and the above-mentioned problems are present.

### Aesthetic Considerations

Chloride - High concentrations of chloride impart a salty taste to water. When chloride is present in concentrations greater than 250 mg/L, it imparts an undesirable taste to water and beverages prepared from the water.

Iron - High concentrations of iron promotes staining, scaling and bacterial activity. When iron is present in concentrations greater than 0.3 mg/L, it may impart a brownish colour to laundered goods; it may produce a bitter astringent taste in water and beverages made from water; and the precipitation of iron may impart a reddish-brown colour to the water. Excessive iron can also promote the growth of iron bacteria in water mains and service pipes.

Manganese - Manganese also promotes staining and is usually associated with iron. When manganese is present in concentrations greater than 0.05 mg/L it can stain laundry and cause objectionable tastes and may lead to the build-up of slimy coatings in piping which can slough off as black precipitates.

Water Treatability

Hardness - No limits are assigned in the "Drinking Water Objective". High concentrations result in scaling and a reduction in the degree of soap lather.

Alkalinity - No limits are assigned in the "Drinking Water Objectives". This parameter can be used to establish the water's encrustation capacity on corrosiveness.

Tracer/Indicator Considerations

pH - No limits are assigned in the "Drinking Water Objectives". Acidity affects solubility of other ions and sampling for other parameters may be desirable if the pH is low (below 6.5). These parameters can be decided on after consulting with local Ministry staff.

Conductivity (or TDS) - This is an index parameter for overall water quality. Extremely high values of total dissolved solids may be indicative of other problem parameter in the water supply.

Local Considerations

Fluoride - High concentrations of fluoride in supplies can be toxic. Lower concentrations can cause the mottling of teeth. This parameter is normally only analysed at the advice of Ministry staff where local knowledge indicates the parameter is likely present in offensive concentrations.

Sulphate - sulphate can have a cathartic (laxative) effect on people not accustomed to water containing elevated concentrations. When sulphate is present in concentrations greater than 250 mg/L it may also contribute to the formation of scale in boilers and heat exchangers.

Miscellaneous - In areas where excesses are suspected, additional parameters should be analyzed (i.e. trace elements in bedrock wells; pesticides in areas of intensive agricultural usage; etc.). Those parameters can be decided on after consulting with local Ministry staff.

# APPENDIX E

## REGIONAL PUBLIC HEALTH LABORATORIES

Appendix E

## Regional Public Health Laboratories

| Name, Postal Address<br>Telephone and TWX Numbers | Street Address |
|---|---|
| **Hamilton** | |
| Public Health Laboratory<br>Ontario Ministry of Health<br>P.O. Box 2100<br>Hamilton, Ontario L8N 3R5<br><br>Phone: (416) 385-5379<br>TWX : 610-371-0257 | Hamilton Psychiatric Hospital<br>Fennell Avenue West |
| **Kingston** | |
| Public Health Laboratory<br>Ontario Ministry of Health<br>Box 240<br>Kingston, Ontario K7L 4V8<br><br>Phone: (613) 546-2686<br>TWX : 610-523-1155 | Government Building<br>181 Barrie Street |
| **London** | |
| Public Health Laboratory<br>Ontario Ministry of Health<br>P.O. Box 5704, Terminal 'A'<br>London, Ontario N6A 4L6<br><br>Phone: (519) 455-9310 | Fifth Floor<br>London Psychiatric Hospital<br>(Off Highbury Avenue) |
| **Orillia** | |
| Public Health Laboratory<br>Ontario Ministry of Health<br>P.O. Box 600<br>Orillia, Ontario L3V 6K5<br><br>Phone: (705) 325-7449<br>TWX : 610-395-0226 | Highway 11B |
| **Ottawa** | |
| Public Health Laboratory<br>Ontario Ministry of Health<br>P.O. Box 6301, Station 'J'<br>Ottawa, Ontario K2A 1S8<br><br>Phone: (613) 828-2442<br>TWX : 610-562-1958 | 346 Moodie Drive<br>R.R. !2<br>Bell's Corners |

Palmerston

Public Health Laboratory
Ontario Ministry of Health
P.O. Box 700
Palmerston, Ontario N0G 2P0

Midwestern Regional Children's Centre
Highway 23

Phone: (519) 343-2015
TWX : 610-366-3140

Peterborough

Public Health Laboratory
Ontario Ministry of Health
P.O. Box 265
Peterborough, Ontario K9J 6Y8

1341 Dobbin Avenue

Phone: (705) 743-6811
TWX : 610-383-0119

Sault Ste. Marie

Public Health Laboratory
Ontario Ministry of Health
P.O. Box 220
Sault Ste. Marie, Ontario P6A 5L6

Albert and Brock Streets

Phone: (705) 254-7132
TWX : 610-344-5002

Sudbury

(Satellite of Timmins Laboratory)
Public Health Laboratory
Ontario Ministry of Health
1300 Paris Crescent
Sudbury, Ontario P3E 3A3

1300 Paris Crescent

Phone (705) 522-2640

Thunder Bay

Public Health Laboratory
Ontario Ministry of Health
P.O. Box 1100, Station 'F'
Thunder Bay, Ontario P7C 4X9

336 South Syndicate Ave.

Phone: (807) 622-6449

Timmins

Public Health Laboratory
Ontario Ministry of Health
67 Wilson Avenue
Timmins, Ontario P4N 2S5

67 Wilson Avenue

Phone: (705) 264-8771
TWX : 610-339-0640

Windsor

Public Health Laboratory
Ontario Ministry of Health
P.O. Box 1616
Windsor, Ontario N9A 6S2

3400 Huron Church Road

Phone: (519) 969-4341
TWX : 610-362-0715

Associate Public Health Laboratory

Sarnia

Public Health Laboratory
Ontario Ministry of Health
Sarnia General Hospital
Sarnia, Ontario N7T 6H6

220 North Mitton Street

Phone: (519) 344-3661

# APPENDIX F

## CHLORINATION PROCEDURE FOR DOMESTIC WELLS

## Chlorination Procedure for Domestic Wells

The following procedure may be used to chlorinate the water in a well by providing a concentration of 250 parts per million of free available chlorine:

1. Measure the diameter of well.
2. Measure the depth of the water in the well.
3. From the following table obtain the volume of water contained in your well for every foot of length.

| Inside Diameter | Imperial gallons per foot Water in the Well |
|---|---|
| 2 inches | 0.14 |
| 4 inches | 0.53 |
| 5 inches | 0.86 |
| 6 inches | 1.22 |
| 7 inches | 1.67 |
| 8 inches | 2.13 |
| 24 inches | 19.5 |
| 30 inches | 30.5 |
| 36 inches | 44.0 |

4. After calculating the number of gallons of water in the well, calculated the amount of chlorine containing material (i.e. household bleach (Javex) or calcium hypochlorite) that is required, using the following relationship:
   16 oz. of Javex solution or 1.5 oz. of calcium hypochlorite for every 100 gallons of water.
5. Before disinfecting the water supply system, remove or by-pass any carbon filter in the system. A filter will tend to remove the chlorine. In addition, the water heater should be completely drained and allowed to fill with chlorinated water.

6. Thoroughly mix the chlorine solution or powder with the water in the well. The recommended method of adding the chlorine (solution, powder or tablets) to the well water, is to mix the chlorine with a volume of water larger than that in the well. This is then allowed to flow into the well displacing the well water into the formation.

   Another method is to place a measured quantity of chlorine powder or tablets into a weighted porous container. This container is then surged up and down in the well until the contents are dissolved.

7. Open all the taps in the pressure system until you can smell chlorine and then turn the taps off. This will thoroughly chlorinate the plumbing fixtures.

8. Allow the solution to remain in the water system for at least 12 hours.

9. After the 12 hours open all the taps until the strong smell of chlorine disappears. The amount of chlorine remaining in the water will not be harmful.

10. In about a week, send a water sample to the local health unit for a bacteriological examination. Boil or chlorinate all drinking water until the bacteriological results are returned. Two consecutive 'safe' tests will probably indicate that the treatment has been effective.

11. If tests show continuing bacteriological contamination, a second chlorination is needed. Following the second treatment additional tests should be conducted. After repeated positive bacteriological tests, a well contractor should be contacted to surge the well and the surrounding formation with a strong chlorine solution.

12. If additional treatment is still unsatisfactory, the source of the problem should be investigated and corrected. A new well may need to be constructed away from the source of contamination.

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Water wells and ground water supplies in Ontario / Gunther, F.

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